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U. S. DEPARTMENT OF AGRICULTURE.
DIVISION OF ENTOMOLOGY.
BULLETIN No. 22.

REPORTS

OF

OBSERVATIONS AND EXPERIMENTS

IN

THE PRACTICAL WORK OF THE DIVISION,

MADE

UNDER THE DIRECTION OF THE ENTOMOLOGIST.

(PUBLISHED BY THE AUTHORITY OF THE SECRETARY OF AGRICULTURE.)

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LETTER OF SUBMITTAL.

DEPARTMENT OF AGRICULTURE,
DIVISION OF ENTOMOLOGY,
Washington, D. C., January —, 1890.

SIR: I have the honor to submit for publication Bulletin No. 22 of this Division. Owing to the necessities of the case I was able to include in the annual report only a general summary of the work of the field agents of the Division, reserving their full reports on the work of the year for subsequent publication. They are, therefore, here presented.

Respectfully,

C. V. RILEY,
Entomologist.

Hon. J. M. RUSK,
Secretary of Agriculture.

INTRODUCTION.

This bulletin comprises the reports of the field agents of the Division of Entomology which were necessarily omitted from the annual report, in which it has been our previous custom to publish some or all of them.

Mr. Coquillett has reported upon several phases of his work, and we print here only the portion relating to the experiments which he made in the destruction of the Red Scale of California (*Aspidiotus* [*Aonidia*] *aurantii* Maskell) by the use of washes. A portion of his report relating to experiments with gas treatment for this scale insect, resulting in the great cheapening of the use of this process, has been printed in the double number of INSECT LIFE for January and February, 1890. Another section of his report relating to the attempted colonization of the insects preying upon *Icerya purchasi*, imported by Mr. Koebele from Australia, has also been published in part in INSECT LIFE for October, 1889, and the remainder is reserved for future use. The experiments with washes were undertaken with a view of presenting a practical illustration of their utility to the fruit-growers of southern California who had apparently ignored the previous results obtained and published in our reports for 1886 and 1887. These late experiments were performed by instruction of Assistant Secretary Willits, and the Red Scale was particularly chosen on account of its importance as a pest, and for the further reason that the Fluted Scale seems at present to require no further experimentation, since the Vedalia is overcoming it so rapidly.

Professor Osborn, in obedience to instructions, has taken up the study of insects injurious to grasses in addition to his regular work upon the insect parasites of domestic animals, and reports at this time upon the leaf-hoppers injuring forage plants. This is a comparatively new and important field of investigation.

Professor Webster continues his studies of grain insects and reports here upon certain points connected with the economy of a few well-known pests.

Miss Murtfeldt sends in a general report upon the insects of the season in eastern Missouri, brings out a number of interesting facts, and gives the life history of a beetle injuring Spinach and also the histories of two interesting Saw-flies.

Mr. Koebele returned from Australia in March and came on to Washington for special work, returning to Alameda, Cal., April 15. He spent considerable time in writing out his report on his Australian work (published in Bulletin No. 21 of this Division) and in assisting to rear and distribute the Vedalia.

During the latter part of the season he did considerable field work and reports upon a number of injurious species. Perhaps the most interesting feature in his report is his work upon the enemies of the Codling Moth in California. He has reared four entirely new parasites of this species, two of which are primary and two secondary. The egg parasite seems to be a very important feature in the life of the Codling Moth on the Pacific coast, and we know from previous experience with egg-parasites of the same genus that they are capable of very rapid development and are consequently very beneficial insects where they attack injurious species. We need only refer to the case mentioned in the Fourth Report of the U. S. Entomological Commission, where by the work of *Trichogramma pretiosa* Riley, the fifth brood of Cotton Worm was almost completely annihilated in Florida, where at the beginning of the fourth brood less than one-half of the eggs had been destroyed. By almost complete annihilation we mean that less than 10 per cent. of the Cotton Worm eggs throughout a large section remained unstung.

Professor Bruner treats of the insects of the year and enters upon the consideration of insects detrimental to the growth of young trees on tree claims in Nebraska and other portions of the West, an important subject which has not before received treatment.

C. V. R.

REPORT ON VARIOUS METHODS FOR DESTROYING THE RED SCALE OF CALIFORNIA.

By D. W. Coquillett, *Special Agent.*

LETTER OF TRANSMITTAL.

Los Angeles, Cal., *October* 30, 1889.

Sir: I herewith submit my annual report on some of the results obtained by me during the past year.

During the first half of the year nearly my whole time was occupied in propagating and distributing the Lady-birds (*Vedalia cardinalis* Mulsant) recently imported from Australia by this Division. So thoroughly have these insects destroyed the Fluted or Cottony-cushion Scale (*Icerya purchasi* Maskell) that at the present time it is difficult to find a living specimen in any portion of the southern part of this State. From the 129 Lady-birds received from the 30th of November to the 24th of January and colonized under a tent covering an orange tree in this city, by the following midsummer I had, with the help of Mr. J. W. Wolfskill and Mr. Alexander Craw, distributed nearly 15,000 of these insects to various parts of the State, which will give some idea of the great fecundity of these insects. My first attempt at colonizing them on trees in the open air was made in the 35-acre orange grove belonging to Col. J. R. Dobbins, and located in the San Gabriel Valley in this county. I colonized 35 of the Lady-birds on one of the trees February 22 and about 100 more on the 20th of March, and Colonel Dobbins writes me that they had practically freed his grove of the Iceryas by the 31st of July.

The large Chapman orange-grove, also located in the San Gabriel Valley, and comprising 150 acres of citrus trees, has likewise been practically cleared of the Iceryas by these Lady-birds, the first colony of which I placed in this grove on the 20th of March. As might naturally be expected, this freeing of the orange-groves from one of the greatest pests with which they were ever infested removes a great burden from the shoulders of our orange-growers; or, as one of them, Mr. A. Scott Chapman, writes to me: "They have taken more than an oppressive burden off of the orange-growers' hands, and I, for one, very much thank the Division of Entomology for the *Vedalia cardinalis*—the insect that has worked a miracle."

One of the most important results obtained by me the past season has been the discovery of a method whereby trees could be treated with hydrocyanic acid gas at a price scarcely exceeding one-third of what it has heretofore cost by the old method. As the great expense attending the use of this gas has been the one great objection to its being universally employed for the destruction of scale-insects infesting trees, this objection having been now overcome we may naturally expect to see this method coming into more extended use than has been the case heretofore. As I have

given a full account of this new discovery in the report which follows, it will be needless to more than call your attention to it in this place. *

As heretofore, I am indebted to yourself for suggestions and other help.

Respectfully, yours,

D. W. COQUILLETT.

Prof. C. V. RILEY,
U. S. Entomologist.

RESIN SOAPS AND COMPOUNDS FOR THE DESTRUCTION OF THE RED SCALE.

Early in July of the present year I received a letter from Mr. L. O. Howard, acting entomologist during the absence of Professor Riley, instructing me to obtain permission from some person owning a number of large-sized orange trees which were thickly infested with the Red Scale (*Aspidiotus aurantii* Maskell), and then have the trees sprayed with one of the most approved resin sprays obtainable, the spraying to be repeated as often as would be found necessary in order to practically free the trees of these pests, or at least to prevent them from becoming so numerous as to interfere with the healthy growth of the trees, the object sought for being to demonstrate that citrus trees badly infested with these pests can be cleaned and kept in a healthy, growing condition by the use of the resin spray.

Before entering upon this work I concluded to make a series of preliminary tests with various preparations, containing resin and other ingredients in varying proportions, with a view of ascertaining the best and most desirable preparation to use in my field work referred to above. Accordingly I went down to Orange, in the adjoining county, which bears the same name, and, on the 17th, 18th, and 19th of July, made fourteen tests with various preparations, repeating one of these and making several additional tests on the 7th and 8th of the following month. The one giving the best results was used a trifle too strong, as I subsequently ascertained that it produced a discoloration on the underside of some of the oranges, or where they came in contact with each other or with a leaf or branch. For this reason a slightly weaker solution would produce better results, and doubtless the following proportions will be found the most effectual to use during the hotter part of the year:

Resin	pounds..	18
Caustic soda (70 per cent. strength)	do....	5
Fish oil	pints..	2½
Water to make	gallons..	100

The necessary ingredients are placed in the boiler and a sufficient quantity of cold water added to cover them; they are then boiled until dissolved, being occasionally stirred in the mean time, and after the

* This portion of Mr. Coquillett's report has been published in advance in INSECT LIFE, Vol. II, double No. 6 and 7 (January and February 1890).—C. V. R.

materials are dissolved the boiling should be continued for about an hour, and a considerable degree of heat should be employed so as to keep the preparation in a brisk state of ebullition, cold water being added in small quantities whenever there are indications of the preparation boiling over; too much cold water, however, should not be added at one time, or the boiling process will be arrested and thereby delayed, but by a little practice the operator will learn how much water to add so as to keep the preparation boiling actively. Stirring the preparation is quite unnecessary during this stage of the work. When boiled sufficiently it will assimilate perfectly with water and should then be diluted with the proper quantity of cold water, adding it slowly at first and stirring occasionally during the process. The undiluted preparation is pale yellowish in color, but by the addition of water it becomes a very dark brown. Before being sprayed on the trees it should be strained through a fine wire sieve, or through a piece of swiss muslin, and this is usually accomplished when pouring the liquid into the spraying tank, by means of a strainer placed over the opening through which the preparation is introduced into the tank.

The preparing of this compound would be greatly accelerated if the resin and caustic soda were first pulverized before being placed in the boiler, but this is quite a difficult task to perform. Both of these substances are put up in large cakes for the wholesale trade, the resin being in wooden barrels, each barrel containing a single cake weighing about 375 pounds, while the caustic soda is put up in iron drums containing a single cake each, weighing about 800 pounds. The soda is the most difficult to dissolve, but this could doubtless be obviated by first dissolving it in cold water and then using the solution as required.

It has been very generally supposed that the finer the spray could be thrown upon the tree the better would be the results obtained, but after conversing with several persons who make the spraying of trees their special work I was somewhat surprised to learn that each of them were in favor of a rather coarse spray. In nearly every instance they had started out with the impression that a fine spray was the best, but had gradually adopted one somewhat coarser, finally adopting one that threw a moderately coarse spray with considerable force. After carefully investigating the subject I found that their reasons for preferring a rather coarse spray to a fine one were well founded.

The object sought for is not so much to simply sprinkle and wet the tree as it is to paint or varnish it over with the compound used, and this can best be accomplished by the use of a rather coarse spray, which enables them to throw the liquid upon the tree with considerable force, so that when it strikes any portion of the tree it spreads out and covers the adjoining parts with a thin film, as if put on with a brush. It also strikes many of the leaves with such force as to cause them to expose to the spray portions of their surfaces that would otherwise escape. Besides this, by the use of a moderately coarse spray the tree can be

wet or varnished over in a much shorter space of time than when a finer spray is used, and all of the operators that I have conversed with on this subject were unanimous in their statements that the time thus saved much more than compensated for the somewhat larger quantity of the preparation that was required when the coarse spray was employed as compared with a finer spray. The evidence, therefore, appears to be decidedly in favor of a rather coarse spray.

But whatever may be the character of the preparation used, or the nature of the spraying nozzle employed, the success of the operation will depend very largely upon the thoroughness with which the preparation has been applied. In the case of small trees it is comparatively easy to wet every part of them, but when the trees are 20 feet or more in height and have not been properly pruned it is not only difficult but quite impossible to wet every portion of them; and, unfortunately, the tendency is to use as little of the preparation upon the tree as is absolutely necessary. On tall trees the operation of spraying is made more effectual by the use of tall ladders, so that the various parts of the trees can be sprayed from above as well as from below.

It is well known among those who have had any experience in trying to destroy the Red Scale with sprays of any kind that the scale insects which are located upon the fruit are less affected by the different liquid preparations than those located upon the leaves or bark. The reason for this appears to lie in the fact that those located upon the fruit, having an abundance of food always within easy reach, are more healthy and vigorous than those located upon the other parts of the tree, and consequently are better prepared for resisting the destructive effects of the spray. That healthy, vigorous insects are capable of resisting the effects of a destructive agency that has proved fatal to their less vigorous comrades there can be no doubt. An instance of this kind is given in my report to Professor Riley for the year 1888, as published in the Annual Report of this Department for that year. On page 128, in speaking of the effects of arseniuretted hydrogen gas upon the Fluted or Cottony-cushion Scale (*Icerya purchasi*, Maskell), the statement is made that "Subsequent experiments made upon perfectly healthy trees and insects showed that when the gas was used strong enough to have proved fatal to all of the Icerya on the neglected trees it did not kill one-half of those on the vigorous trees." Owing to this fact it would be advisable to refrain from irrigating and cultivating infested orange trees for several weeks before spraying them, were it not for the other fact that in the case of bearing trees such a course would seriously interfere with their bearing qualities or operations. Unlike deciduous fruit trees, our citrus trees do not take a rest of several months' duration between the ripening of the fruit and the blossoming of the trees for another crop; only a few weeks at the most intervening between these two periods in the case of orange trees, while on healthy bearing lemon trees both blossoms and fruit are to be found at every season of the year.

In the case of bearing orange trees it would appear that the season of the year when they could be sprayed with the least amount of injury to themselves and with the greatest fatality to the red scales infesting them would be at a time when they were in blossom, after all of the fruit of the preceding season had been removed from them. There would at such a time be no fruit on the trees for the scale-insects to locate upon, so that all these insects that could be reached by the spray would be destroyed without at the same time injuring any portion of the tree. Several persons who had sprayed their orange trees at a time when the latter were in full bloom informed me that to all appearances none of the blossoms were injured by the spray, providing that the latter was not used so strong that it injured the leaves, being unanimously of the opinion that the blossoms were as hardy as the leaves. The young fruit is much more susceptible to the effects of the spray than are either the leaves or the blossoms, and this is the case until it becomes at least half-grown. It has been my experience, and also the experience of others with whom I have conversed upon the subject, that where the conditions are equal an orange tree is more susceptible to the effects of a given spray than a lemon tree, the foliage of the latter being hardier; whereas in the case of frosts the reverse of this is true, lemon trees being greatly injured by frosts that would produce little or no effect upon orange trees growing under similar conditions.

It is a well-established fact that any given spray will not be so fatal to the scale insects during the cooler portion of the year as it will if applied during the hotter portion. On this account it will evidently be found necessary during the winter months to use a somewhat stronger solution than indicated in the formula given above; and probably the proper proportions to use during this season would be obtained by adding water sufficient to make only 80 gallons, instead of 100 gallons as given in the above formula.

What is true in regard to the effects of the solution upon the insects is equally true of its effects upon the tree, the same solution that would not injure the tree if applied during cool weather might injure it very severely if applied during very warm weather. As bearing upon this subject, I can not do better than to give the experience of one of my correspondents, Mr. F. G. Ryan, an intelligent orange-grower of Anaheim, in the adjoining county of Orange. Mr. Ryan used the resin compound quite extensively for the destruction of the Black Scale (*Lecanium oleæ* Bernard), and under date of February 7, 1889, he writes me as follows:

I want to tell you of a disappointing experience I had with the resin compound. On January 21 and 22 I sprayed twelve trees in one quarter of the grove and eight in another with a compound composed of 1 pound of caustic soda, 8 pounds of resin and 32 gallons of water. After doing this a hot, drying wind arose and stopped our work. The wind continued for several days, becoming milder each succeeding day, and on the fourth day I noticed some leaves dropping from these trees; this dropping of the foliage has continued and increased until now there is scarcely half the foliage left

on two or three of the trees, and the others show a loss of from 15 to 50 per cent. I argue that as the trees first sprayed show a lesser loss than the others, the probabilities are that the water and compound were not thoroughly mixed, and as it is my custom to keep the inlet pipe of the pump near the top of the solution to avoid the sediment, these trees received a weaker solution, as the compound would remain at the bottom of the tank until thoroughly mixed and suspended in the water. No conditions of health of trees or soil affected the loss of foliage, since similar results are shown by the trees in the other part of the grove. My conclusion is that the cause exists in too strong a solution, followed by hot, dry winds for several days. Since the date of spraying there has been no rain nor even a fog or cloud until two days ago. I am happy to say, though, that the bugs are dead.

That this disastrous result to the foliage was the direct effect of the hot drying wind appears to admit of no doubt, since Mr. Ryan informs me that when no such wind prevailed he had sprayed a large number of his orange trees with a compound made precisely like the one used above, and the trees thus sprayed dropped scarcely a leaf. The fact that the latest trees sprayed suffered the most indicates not so much that they were sprayed with a stronger solution than the others, but rather that being sprayed later and being still wet with the solution they would naturally be more affected by the hot winds than those which were sprayed earlier, and from which the surplus solution had had time to drip off, while the remainder would be quite dry before the hot wind occurred.

Following is an account of a number of experiments which I made with various resin compounds and resin soaps for the destruction of the Red Scale (*Aspidiotus aurantii* Maskell); they were made at Orange, in the adjoining county of Orange, upon trees kindly placed at my disposal by Mr. H. F. Gardner. The trees in experiments 181–194 contained no fruit, but there were green oranges on all of the other trees experimented upon.

In making each of these solutions the necessary ingredients were placed in the boiler, covered with water, and boiled briskly from two to three hours, after which they assimilated well with water; the solution was then diluted with the proper quantity of water, strained through a piece of barley sack, and then sprayed upon the tree. In each instance only a small quantity of solid or semi-solid matter was strained out of the different solutions. An exception to this occurs in experiments 185 and 186, in which the resin was simply dissolved in water over a hot fire, after which the necessary quantity of water was added and the solution strained, as described above. In dissolving the resin I used 3 gallons of water for each pound of the resin; at first I tried to dissolve it at the rate of 1 pound of resin to 2 gallons of water, but a portion of the resin would not dissolve until more water had been added. The solution was of a milky-white color, and assimilated well with water.

The cost per 100 gallons of the different preparations as given below is based upon wholesale prices of the different ingredients, furnished me by the Los Angeles Soap Company, of this city. The rate on resin is by the 10-barrel lot of 375 pounds per barrel; of caustic soda, by the

drum of 800 pounds; of fish-oil, by the barrel of 50 gallons; of potash, by the cask of 700 pounds; and of tallow, by the barrel of 375 pounds.

(181) Resin, 25 pounds; caustic soda, 3 pounds; water to make 100 gallons; costs 65 cents. The diluted solution was of a light brown color. Sprayed on an orange tree at 11.30 a. m., July 17, sun shining, light breeze. August 6, foliage uninjured; found a great many live scales.

(182) Resin, 33 pounds; caustic soda, 4 pounds; water to make 100 gallons; costs 84 cents. Sprayed on an orange tree at 11.45 a. m., July 17, sun shining, light breeze. August 6, foliage uninjured; found great many live scales.

(199, 200) Resin, 25 pounds; caustic soda, 6 pounds; water to make 100 gallons; costs 77 cents. Sprayed on two orange trees at 10.45 and and 11 a. m., August 7, sun shining, light breeze. September 2, found great many live scales, especially on the fruit; leaves uninjured; many of the half-grown oranges have rusty, brownish spots on their under sides, or where they came in contact with each other or with a branch or other object. These spots were still present October 19, but whether they will disappear or not before the fruit ripens remains to be seen.

(201) Resin, 33 pounds; caustic soda, 8 pounds; water to make 100 gallons; costs $1. Sprayed on an orange tree at 11.15 a. m., August 7, sun shining, light breeze. September 2, same as in the preceding experiment.

(190) Resin 16 pounds, fish-oil 6 pints, caustic soda 6 pounds, water to make 100 gallons, costs 85 cents. The diluted solution was of a very dark brown color. Sprayed on a lemon and orange tree (*i. e.* orange budded to lemon, but the orange branches not cut away) at 1:30 p. m., July 18, sun shining, light breeze. August 6, leaves and newest growth uninjured; found ten live scales.

(191) Resin 22 pounds, fish oil 1 gallon, caustic soda 8 pounds, water to make 100 gallons; costs $1.15. Sprayed on an orange tree at 2 p. m., July 18, sun shining, light breeze. August 6, a few of the older leaves have brownish spots on their under sides; found three live scales.

(192,195) Resin 20 pounds, fish oil 3 pints, caustic soda 6 pounds, water to make 100 gallons; costs 80 cents. Sprayed on a lemon and on an orange tree at 1 and at 12:10 p. m., July 19, and August 7; sun shining in the first, cloudy in the second experiment, light breeze. August 6, in first experiment leaves uninjured; found two live scales. September 2, in second experiment leaves uninjured; found 12 live scales on the fruit and 8 on under side of the leaves where they had evidently escaped the spray. In both experiments the fruit was as described in experiment 199 above, but to a less degree.

The formula in these two experiments was the same, except that in 192 one pound more of the resin was used than in 195; but this small quantity in 100 gallons could scarcely have affected the results. This is the same formula used on September 3 of the present year (1889) for spraying twenty-five orange trees, in accordance with instructions

from Mr. Howard, referred to above. Two of the trees were 5 feet tall by 4 in diameter, while the others ranged from 14 to 18 feet tall by from 12 to 16 feet in diameter. They were sprayed between the hours of 3 and 5.30 p. m.; sun shining, light breeze. Three hundred gallons of the diluted compound were used. A tree 16 feet tall by 14 feet in diameter required about 14 gallons of the compound, and three men and a spraying outfit will spray about 800 gallons in a day. The cost of materials and labor in spraying with this compound a tree of the size indicated above amounts to about 24 cents per tree. I examined the above-mentioned trees September 24, and again October 19, and found that the leaves and fruit were uninjured, but a few of the oranges had small brown spots on them as described above in experiment 199. Nearly all of the scales located on the leaves and bark were dead, but about one-fourth of those located upon the fruit were still alive.

(193, 196) Resin 28 pounds, fish oil 4 pints, caustic soda 8 pounds, water to make 100 gallons; costs $1.10. Sprayed on two orange trees at 1.15 and 12.20 p. m., July 19 and August 7; sun shining in the first, cloudy in the second, light breeze. August 6, September 2, and October 19, leaves uninjured; some of the oranges had brown spots on them as described above in experiment 199; found only one live scale on the leaves, and three on the fruit.

(202) Resin 21 pounds, fish oil 3 pints, crude potash 4 pounds, water to make 100 gallons; costs 85 cents. Sprayed on an orange tree at 12.30 p. m., August 8; sun shining, light breeze. September 2, leaves uninjured; some of the oranges had brown spots on them as described above in experiment 199; found many live scales both on the leaves and fruit.

(203) Resin 28 pounds, fish oil 4 pints, potash 5½ pounds, water to make 100 gallons; costs $1.15. Sprayed on an orange tree at 1 p. m., August 8; sun shining, light breeze. September 2, same as in the preceding experiment.

(183) Resin 20 pounds, tallow 6½ pounds, caustic soda 6½ pounds, water to make 100 gallons; costs 98 cents. Sprayed on a lemon tree at 12 m., July 17; sun shining, light breeze. August 6, a few of the older leaves were injured; found great many live red scales.

(184) Resin 25 pounds, tallow 8 pounds, caustic soda 8 pounds, water to make 100 gallons; costs $1.22. Sprayed on an orange tree at 12.30 p. m., July 17; sun shining, light breeze. August 6, leaves uninjured; found three live red scales.

(188) Resin 17 pounds, tallow 6 pounds, caustic soda 6 pounds, water to make 100 gallons; costs 88 cents. Sprayed on an orange tree at 1 p. m., July 18; sun shining, light breeze. August 6, leaves and newest growth uninjured; found twelve live red scales.

(189) Resin 22 pounds, tallow 8 pounds, caustic soda 8 pounds, water to make 100 gallons; costs $1.16. Sprayed on a lemon tree at 1.15

p. m., July 18; sun shining, light breeze. August 6, leaves uninjured; found fourteen live red scales. The pupæ and recently transformed adults of the Chalcid fly, *Dilophogaster californica* Howard, which infested fully 80 per cent. of the black scales (*Lecanium oleæ* Bernard) on this tree, were all of them destroyed by this spray.

(187) Resin $2\frac{2}{3}$ pounds, tallow 14 pounds, crude potash $5\frac{1}{2}$ pounds, water to make 100 gallons; costs $1.10. Sprayed on a lemon tree at 4.30 p. m., July 17; sun shining, light breeze. August 6, leaves uninjured; found three live red scales.

(185) Resin 19 pounds, water to make 100 gallons; costs 38 cents. Sprayed on an orange tree at 4 p. m., July 17; sun shining, light breeze. August 6, leaves and newest growth uninjured, but few of the red scales were destroyed.

(186) Resin 22 pounds, water to make 100 gallons; costs 44 cents. Sprayed on a lemon tree at 4.15 p. m., July 17; sun shining, light breeze. August 6, same as in the preceding experiment.

EFFECTS OF THE EUREKA INSECTICIDE ON THE RED SCALE.

On the 1st of August of the present year I received a letter from Acting Entomologist Howard, dated July 25, 1889, requesting me to make a test of the "Eureka Insecticide," put up by E. Bean, of Jacksonville, Fla., who would forward me a few sample cans of the insecticide for this purpose. These samples reached me in due time, and I carefully tested the preparation according to directions. One pound of it was emptied into a vessel, 6 gallons of cold water added, and the whole frequently stirred. After the lapse of one hour I allowed the insoluble portion to settle to the bottom of the vessel, poured off the clear liquid portion, and sprayed it upon an orange tree at 2 p. m., August 7; cloudy, light breeze. September 2 the leaves were uninjured, and I could not discover that any of the red scales (*Aspidiotus aurantii* Maskell) that were encased in a scale or shell at the time the application was made had in the least been affected by the spray.

In a circular received from the proprietor it is stated that this insecticide is sulphur in solution, a patented process, and that it "is absolutely fatal to the rust mite, and also to the scale insect during the breeding or migratory periods," providing that the applications extend through the entire season. It is possible that this insecticide would prove fatal to the recently hatched red scale, but as this becomes covered over with a shell inside of twenty-four hours after leaving the parent, and as the young ones appear during almost every day in the year, it follows that in order to be effective it would be necessary to apply this insecticide every day for three or four months consecutively—a task which very few of our fruit-growers would be willing to perform.

REPORT ON INSECTS OF THE SEASON IN IOWA.

By Prof. HERBERT OSBORN, *Special Agent.*

LETTER OF TRANSMITTAL.

IOWA AGRICULTURAL COLLEGE,
Ames, December 11, 1889.

SIR: I beg to submit herewith my report upon the season's observations and study for 1889.

I have during the season made a series of tests of X. O. Dust under directions from your office; reports of which were transmitted immediately on completion of the tests, and have continued to work, conjointly with yourself, on the insects affecting domestic animals. As bearing upon the same general subject, and connected with one of the most important industries of the State, and, indeed, of a large part of the United States, I have given such time as I could to the study of insects affecting meadows and pastures. Believing, however, that more could be accomplished by giving attention to some particular group, and considering the great importance of the Leaf-hoppers and other Homoptera, and the fact that they have been but slightly studied in this connection, I have spent most of the time upon this group.

The study of these is rendered more difficult in consequence of the great number of species as yet undescribed, and the lack of any complete literature upon known American species. But for these very reasons there is the more need of their being investigated. My results seem meager for the time devoted, but I believe that with the material now brought together much more rapid progress can be made in future studies.

Thanking you for the many favors received from your office, I am
Very respectfully,

HERBERT OSBORN.

PROF. C. V. RILEY,
U. S. Entomologist.

GENERAL OBSERVATIONS.

While no wide-spread devastation has occurred in the State during the past season there has been a considerable amount of damage from a number of different species affecting various crops and operating in different parts of the State.

Cut-worms of different species were unusually abundant, and I received specimens and inquiries regarding them from different parts of the State. They were quite troublesome in gardens, nurseries, and fields in this locality.

The Turf Web-worms (*Crambus exsiccatus*), reported on in detail two years ago, were again quite abundant, but not so numerous or destructive as in 1887. An allied species (*Crambus laqueatellus*) was quite

abundant in the adult form in the latter part of May, and there is good reason to believe that the larvæ have the same destructive habit in grass, and, from the occurrence of the imago so early in the season, it would seem probable that as in *exsiccatus* there are two broods each season.

Another moth nearly related to these web-worms occurred this season in great numbers in pastures and meadows, and though I have not had opportunity to study the larval stage, it may be well to call attention to it as a probable grass pest that may prove as troublesome as the species of *Crambus*. This is the *Nomophila noctuella*, and it was noticed in greatest abundance from May 18 to 22 (1889). The species has been observed as abundant in previous seasons and is probably a pretty constant inhabitant of grass land.

During the latter part of May and first part of June the Blue Grass in the vicinity suffered from the trouble called "Silver Top," the head and upper joint of the stalk turning whitish. I examined a number of these withered and partly wilted stalks and in a few cases found *Thrips* present, and in some cases swollen joints appearing as if affected with *Meromyza*, the adults of which were very plentiful on grass a little earlier. If due to *Thrips*, I think they must leave the grass almost as soon as it begins to wither, as in the cases where I found them I selected stems that were just beginning to turn white.

The Clover-seed Midge has appeared in this State, and the present year is the first I think that it has been destructive. It has been reported in a few localities and I swept the adults from clover in considerable numbers May 25. A very few were bred from clover heads in 1888.

Epitrix cucumeris was very abundant on potatoes, but as the vines had a very vigorous growth in the early part of the season no serious damage resulted.

Diabrotica vittata and *D. 12-punctata* were exceedingly plentiful and furnished me material for some tests of X. O. Dust hitherto reported. I also tried for these a mixture of London purple and kerosene emulsion for the purpose of killing the beetles gathered on the squash vines and preventing the complete destruction of foliage, depending upon the London purple to kill the beetles gathering on the vines later. After this application the vines did very well and I think the plan a success. The beetles will, some of them, fly away before the kerosene takes effect, but they probably all die in a short time. I have since noticed that Prof. John B. Smith has used a similar plan for treating the Elm-leaf Beetle, and it would seem to be applicable in many cases where the expense is not an obstacle and where it is desired to kill the bulk of the insects gathered on plants before they have time to destroy foliage, which they must do to some extent when treated with London purple.

Plant lice of many species were abundant in the latter part of the season. Of these the Thorn-tree Aphid (*Schizoneura crataegi* Oest.) was especially conspicuous by its abundance on thorn trees. The common

Willow Plant-louse (*Melaxanthus salicis*) was brought or sent me a number of times, showing that it attracted unusual attention, and the eggs deposited by the oviparous females were to be found in numbers under the buds of willow twigs in late autumn. Of all the species noticed, however, the swarms of the Dogwood Aphid (*Schizoneura corni* Fab.) were most remarkable. This species is referred to more particularly in another place.

OBSERVATIONS ON INSECTS AFFECTING GRASSES.

The importance of the pastures and meadows in this State will be conceded by every one familiar with its agriculture. Perhaps no other single element is of greater importance, furnishing, as it does, the basis for the stock industry of the State.

The insects infesting meadows and pastures are therefore of the greatest importance, and while their depredations are perhaps less conspicuous than those from insects affecting some other crops, I think it can be clearly shown that the average annual loss in pastures and meadows from insect injuries is equal to if not greater than the crop harvested or the amount consumed by cattle, horses, or sheep in pasture, and probably furnishing a total annual loss greater than in any other crop. In ordinary pasturage it is common, I believe, to allow two acres of land to each cow, or, for convenience, let us say that one acre will half support a cow. At the same time that this cow is feeding there are a million insects, more or less, of various kinds feeding upon the same area by day and night from the time the snow melts in spring till winter forces them to suspend their work.

The only compensation they can offer is that when dead (and they die young), their million little carcasses dropping on the surface of the soil return to it some of the material which has been built into their tissues, increasing its richness and helping to support succeeding generations.

In my report upon the Turf Web-worm two years ago, I gave the count of burrows that had been opened by squirrels as twenty-five in one instance and fifty in another, within a square yard, and it is not probable that every burrow within those areas had been opened by squirrels. The web-worms were, however, uncommonly abundant that season. If we reduce the mean of these figures by one-half and allow two web-worms to each square foot it means 87,120 to the acre, and then consider that these worms cut down quantities of grass that they do not devour, it would seem hardly too much to suppose that these alone would prove a pretty even match for one half a cow in disposing of the grass growing on an acre.

All are familiar with the depredations of white grubs, and it is hardly necessary to ask whether in seasons when these are plentiful they do not destroy as much or more than would support at least half a cow.

Cutworms and Army worms are a constant source of loss in grass

land, and these with the grasshoppers, familiar to everybody, are capable of mowing down a quantity of grass during a season which ought to be appreciated by the farmer. Grasshoppers need not be remarkably plentiful to place a dozen to a square yard, over 50,000 to the acre, and is it any wonder that pastures run short in seasons when rain is scarce or grasshoppers a little more plentiful than usual?

The kinds of insects so far mentioned perform their work in a way that causes an actual lessening of bulk in the crop, but there is another host, less noticeable in size as well as in method of work, whose actual damage in reduction of available food for stock must be of very great importance. These, like the Chinch Bug, which is one of their number, simply puncture the leaves or stems of the grass and pump out its juices, thereby abstracting much of the best food material even where they do not cause a checking of growth and shriveling of the plants. Many of these are insects of very minute proportions, but like the Chinch Bug make up in numbers for their diminutive size. It is no exaggeration I think to say that they occur by the million to the acre.

A million mouths against a half a mouth, and is it necessary that the individual mouth be a very large one to make the aggregate food consumed equal that of the half cow?

In order that my figures may not seem purely fanciful, I may state that they are derived in part from actual count, but in all cases, when count has been made, the circumstances have been such as to make the numbers fall short of the actuality.

I have captured leaf-hoppers on grass by throwing a net down vertically and counting the number caught within the area inclosed by the ring, and while it is hardly possible in this way to secure all that were actually within that area the average of a number of such captures gives nearly a million to the acre.

I have many times observed them when plentiful and tried to count the number within a given area, but their activity makes this difficult. By approaching them very slowly and keeping very quiet, I have on some occasions been able to observe them closely and have on different occasions been able to count many within the area of a few square inches; often two or more to a single blade of grass, and consequently I feel satisfied that the estimate based on the numbers captured are far below the actual numbers frequently occurring during seasons when they are ordinarily abundant and greatly under the number in seasons when they have multiplied to any unusual degree. It may perhaps be urged that, even allowing them to abound in this degree every season, they are too small to consume a very great amount of food. Possibly a million leaf-hoppers would not exceed in bulk the half of an average cow, but it should be remembered also that they grow very rapidly and must consequently use proportionately large quantities of food, and that they extract the most nutritious parts of the grass. That grass forms the bulk of their food has not I think been questioned, but to be certain on

this point I have observed them carefully and examined with particular care the grass blades on which I have seen them established.

On September 7, 1889, I swept grass where no other living plants were to be seen and collected numerous Hemiptera of a number of different species, mostly Homoptera. The grass was very dry, brown, and in many places appearing dead, but evidently still furnishing support for the leaf-hoppers. There were but few other insects present, scarcely any that could be supposed to feed upon grass, except some grasshoppers (*Caloptenus femur-rubrum*, species of *Œdipoda*, etc.). The species of Homoptera collected may I think be considered as unquestionably grass feeders. No other vegetation that could furnish them support had been on the ground swept for weeks, and the insects swarmed on every square foot. The grass commenced turning brown in patches long before it should be expected to, if affected only by want of rain, as it showed within a short time after the last rains, which had been quite regular and copious, previous to the dry period of that time, and its drying up must have been hastened by losses due to the presence of insects. The ground was not yet dry enough so that the grass could have suffered from lack of moisture alone. Their presence on grass seems to show its effect in two ways, though for one of them it is difficult to draw the line between the effects of leaf-hoppers and dryness. In one the effect of punctures shows in numerous pale and dry spots on the blades of grass resembling effects produced by related Homoptera on other plants, apple-trees, pear-trees, grape-vines, etc. Such spots can not be found, however, in such numbers as would be expected if there were one for every puncture by the millions of these insects that occur in every piece of grass land. But the great bulk of the grass is withered or dead down to a certain point near the ground (or to the ground), which would naturally be the appearance if the leaf withered from the lower punctures to the tip, thus obliterating all punctured spots on the terminal portion.

The difference between grass withering from punctures and from lack of moisture is perhaps not sufficiently different to furnish a very safe basis for deduction, but in the latter case it is naturally more gradual and holds for a longer time the green color of hay, so that for withered grass not too long exposed I believe we should be able to distinguish in some degree the difference between that killed by leaf-hoppers and that dried by excessive heat and lack of moisture in the ground.

While this may fall short of actual demonstration, I think a careful study of the effects in the field will convince any one that my conclusions are justified by the facts and that, taking year after year, the amount of injury caused by insects of various kinds is fully equal to the amount consumed by the stock ordinarily pastured on the same land. It is evident, then, that the prevention or the reduction of the insect injuries would add an equivalent amount to the return from such land. Instead of one cow requiring two acres for pasturage, pastures comparatively free

from insects should support a cow to each acre through the entire season. It is certain that much of this loss can be prevented by simple and inexpensive means. The capturing of the moths of Turf Web-worms and Cut-worms will help much in reducing their number. Grasshoppers can be destroyed at the same time that Leaf-hoppers are, and by use of the same means, and it would seem certain that a method costing but 2 to 10 cents per acre might be applied with great profit for these insects alone. It is my object here, however, to treat in detail only of the remedies tried or proposed for Leaf-hoppers.

APPEARANCE AND HABITS OF LEAF-HOPPERS (JASSIDÆ).

The insects embraced in this group are almost all small and rather slender insects, with blunt or pointed heads and well-developed wings, which at rest lie parallel along the back, usually sloping like a roof, or partly inclosing the body. One of the most characteristic features, however, is their habit of leaping when disturbed. All the species possess this habit, though some do not leap as readily as others. The largest species common to grass are not over half an inch in length, while the smaller ones are less than an eighth of an inch long. Many of the species are extremely light and slender, almost invisible except when carefully observed, while others have short, thick bodies. Their colors are well adapted to furnish them protection, many being green, others yellowish or brownish, and in many cases they will not be noticed at all on the grass until they leap, and then it is usually because of the swarm that rise together that they become noticeable. All feed by puncturing the plant and sucking out the juicy contents of the leaves or stems. All, so far as known, puncture leaves or stems of plants to deposit their eggs, frequently placing them under the epidermis only. The larvæ are commonly somewhat spiny at first and have the general form of the adults, passing by gradual development with little change through pupa stage to adult. Most of the species, if not all, pass the winter as adults.

REMEDIES FOR LEAF-HOPPERS.

Burning.—For those species of leaf-hoppers which hibernate in grass, and especially those which are active there during late fall and early spring, a thorough burning over should prove of great advantage. The Leaf-hoppers leap readily, but do not ordinarily fly any distance, and especially when the weather is cool would be unable to escape from the flames. In two pieces of grass land burnt over last spring and convenient for observation one showed fairly good results, keeping its color well till late in summer, though surrounded by grass land, unburnt, on three sides. The other, a pasture of some size, was in poor condition all summer; but in this Turf Web-worms and Cut-worms were so plenty that they alone were sufficient to account for its poor condition.

Plowing.—There seems little ground for hoping that the number of Leaf-hoppers can be diminished materially by any system of plowing under, or by rotation of crops. Grass is an essential on every farm, and no system of starvation could be adopted, and even if deprived of the common pasture grasses, the most of the species evidently thrive on the fox-tails and other grasses that flourish as weeds. The leaf-hoppers are too active to be plowed under and can readily migrate to other fields. Eggs for most of the species, at least, are not deposited at any fixed time of the year, and while by plowing under in May, June, or August many eggs might be buried, plenty of hoppers would escape to the surrounding grass land to keep the farm well stocked.

Mowing.—When the grass in which Leaf-hoppers have been very abundant is cut short, leaving only a dry stubble, the insects seem to be forced to migrate, as few or none can be found in such places a few days after the cutting nor until a new growth gives them a source of fresh food supply. While early cutting of meadows badly infested might result in saving a larger crop, it must follow that the Leaf-hoppers would travel to pastures or other grass land, and it would be simply a question as to where they would do the greater amount of damage. It would seem feasible, however, to take advantage of the time when the crop has been just removed to use hopper dozers or other means for capturing them before they have left for fresh pasture. We know, as yet, too little as to where and when the bulk of the eggs are deposited to say whether cutting at any particular time would result in the destruction of any number of eggs. While we know that Leaf-hoppers deposit eggs in stems and leaves of plants, we are not acquainted with their full history or the methods of different species, so that it would be unsafe at present to base remedies on this part of their history.

Capturing in Nets.—The ease with which all species of leaf-hoppers affecting grass can be taken in sweep-nets led me to try the use of this principle on a larger scale. I therefore had a couple of wire frames made 3 feet long, fastened a deep cheese-cloth net to each and attached these to two long handles, so that the frame of one would brush the ground about a foot behind the forward one. The object of having two nets was to secure the hoppers which allowed the first wire to pass over them before leaping. With the handles the net was pushed forward so that the insects were not disturbed till the approach of the net and a strip of ground a yard wide was gone over either at a walk or a run. While numerous insects were secured by this plan, Grasshoppers, Moths, Clover-seed Midges, and large numbers of Leaf-hoppers, the count of those secured from the nets showed that as compared with what must actually exist on the same ground as shown by other captures, only a portion of the Leaf-hoppers were thus secured, and considering the trouble of holding and destroying all the insects captured, I concluded that this plan was not equal to the hopper-dozer for this purpose. The second net captured a goodly number of insects as well as the forward

one and probably held them better, as they could not as readily fly out after having entered. It was found that more insects were captured when the net was pushed at a run that when walking. Probably even then many insects succeeded in flying out of the forward net.

Nets arranged in this manner, two or even three in succession, might be made eight or ten feet long and run by boys, one at each end. The forward net should be closed as soon as a stop is made, and the nets all closed at the finish, when they may be left a day or two for the insects to die. Usually there are enough predaceous species captured to kill the others rapidly, and such species could then be set free. Many species of insects beside the Leaf-hoppers are caught by this device, and some, such as the moths of Turf Web-worms, and Cut-worms, small Diptera, Clover-seed Midges, etc., that are not as apt to be taken in the hopper dozer.

Hopper Dozer.—This simple contrivance (a sheet-iron pan containing kerosene and water or coal tar, to be dragged over the infested ground), devised for the destruction of the Rocky Mountain Locust, possesses the essential qualities for the destruction of the Leaf hoppers as well. I believe that it can be used with profit in any pasture affected with these pests. The delicate Leaf-hoppers are killed by the kerosene almost the instant they touch it, and though my trials with it were made when the weather was so cool that the hoppers did not leap with their usual activity, they showed that it would operate successfully. It would be best, probably, to use it for these during warm days, when the insects are at their greatest activity, and early enough in the spring to catch the hibernating adults before they deposit eggs, repeating the operation, if necessary, in July, and for meadows immediately after the removal of the hay crop. Perhaps two pans, one behind the other, will prove advantageous.

The Shield Method.—A plan that is scarcely more than a modification of the above has been recently highly recommended for the destruction of the Leaf-hoppers infesting grapes. A quite similar plan was adopted for the destruction of the Rocky Mountain Locust years ago and is described in the first report of the United States Ent. Com.; and in his first annual report as State Entomologist of New York, Professor Lintner suggests its use for "low-feeding insects" "especially hopping species." I have not as yet tested it myself, but will give the plan, that others may test it for these insects if disposed. A piece of drilling or, what would be cheaper still, a strip of building paper is fastened to a light wooden frame and is coated with coal-tar or gas-tar, the residue from distilling off kerosene from petroleum, or from gas manufacture. In case of grape Leaf-hoppers this frame is held as near the vines as possible by one man, while another lifts the branches. The hoppers darting against the shield are caught and killed. For grass Leaf-hoppers the frame would be set on runners and could be made 10 to 15 feet long and run by a boy or man at each end. The best angle at which to

hold it would be soon determined by trials, and if sloping back it might be that the underside of the shield, if coated with the tar, would capture hoppers as well as the upper. As coal-tar can be secured in most towns at small expense, and as the frame for the shield costs but little, this method should be applied at a cost of not more than 5 to 8 cents per acre, and could be repeated two or three times during a season if either Grasshoppers or Leaf hoppers become plenty.

It could be used in meadows or tall grass by mounting the frames on runners high enough so that the grass while being bent over should have plenty of room to pass under the shield, but would not be likely to work well when pollen is flying from the grass blossoms or when the seed begins to fall, as the tar would so soon become covered with the dust and chaff.

NATURAL ENEMIES OF LEAF-HOPPERS.

But little is known regarding natural enemies for these active little insects. I have found the common *Coriscus ferus* very plenty in all grass land examined, and where but few other insects were present to furnish it food. When left in nets with Leaf-hoppers the latter are soon found dead, while the *Coriscus* thrives, and knowing their very carnivorous habits, there can, I think, be no question as to their serving a useful purpose in killing these as well as other grass pests. As this species does not have the leaping habit it is less likely to be destroyed in "hopper dozers" than the hopping species, and consequently these remedies can be used with little danger of destroying this natural check to the multiplication of injurious species.

SPECIES OF LEAF-HOPPERS OBSERVED IN GRASS.

The Tenderfoot Leaf-Hopper.

(*Diedrocephala mollipes* Say.)

This widely distributed species is perhaps the most abundant of its genus, and is unquestionably a source of much loss in pastures and meadows. Professor Uhler states its range as "Texas, Colorado, Mexico, and the southern part of the Atlantic region." It is one of the most abundant insects in the Upper Mississippi Valley, and I have found it in great numbers on blue-grass and on prairie grasses, where this must have been its principal, if not only, source of food. Other grasses would seem to serve it equally well. Professor Uhler says (Standard Natural History, vol. II, p. 249):

> The salt marshes of the Atlantic States furnish places of shelter for it, where it may be found on reedy grasses in all stages from June till October.

That it prefers moist places is evidenced by its comparative scarcity on high ground in dry seasons, and its greater abundance in the vicinity of thickets as well as in low ground at such times. It is about one-

third of an inch long, of a bright grass-green color, the head and thorax above yellow. It varies considerably in size, and the females average considerably larger than the males. The head is sharply pointed, has a number of fine black lines on its upper surface; the face is shaded dark brown, and has a double series of transverse bars.

The larvæ which appear to be most common in early summer are light green or yellowish, and agree with the adults in having the head sharply pointed. I have found them most common in May and June, and, as adults are abundant from this time till autumn, it is difficult to say whether there is more than one brood. I have not seen adults in winter or early spring, and it seems possible that eggs in this and allied species are laid in fall to hatch in spring. As this would be contrary to the habit of the majority of insects in this family it will require further observation to establish it. It is at least quite certain that they do not hibernate as adults in grass, and unless eggs are deposited in stems of grass or other plants in grass land the insect can not be destroyed by burning in early winter or spring. It will be seen that there are important points to determine about this very common insect, and means of destroying it may depend in large degree upon the determination of some of the very simple steps in its life-history. It jumps readily, and like other members of the family may be treated on the "hopper-dozer" plan.

The New York Leaf-Hopper.

(*Diedrocephala noveboracensis* Fitch.)

This species is a little larger than the *mollipes*, but resembles it very closely. Its head, however, is less acute, and there are four distinct black spots on the front margin of the head, two of them close together at the tip and one each side in front of the eyes; the lower surface of the head lacks the brown color of *mollipes*, or is but faintly browned. Their habits appear to be much the same, and they are often found in the same locations, though I have found this species more commonly in the grass in wooded pastures or at the borders of thickets. I have never observed it in such abundance as I have the *mollipes*, and ordinarily it is probably of little importance. With equal numbers it would of course be as serious a pest as any of the other species of the family. Professor Uhler says it is common in many parts of the United States north of Maryland and it extends north into Canada and British Columbia.

(*Diedrocephala versuta* Say.)

This species bears a striking resemblance to *coccinea*, and has very similar habits, occurring in similar localities, and probably living upon the same plants. While Say's description was published in 1831 I know of no reference to the species in works on Economic Entomology, and

no reference that would indicate its occurrence in destructive numbers. It is introduced here as one of a group of insects whose importance will I believe be more appreciated when their habits become better known.

The Red-backed Leaf-Hopper.

(*Diedrocephala coccinea* Forster.)

So far as I have observed this is not an abundant species, and while evidently common throughout the United States I know of no record of its multiplying to numbers sufficient to make it destructive. I have found it usually in the vicinity of timber or thickets, and while it probably subsists on grasses does not select the open meadows or pastures but localities affording more moisture and shade. It is a handsome and conspicuous species, the upper surface when wings are closed being largely of a deep red color with dark blue or blue-green stripes. It was described under the name of *Cicada coccinea* by Forster (J. R.), in 1781 (Novae. Spec. Insect., p. 96), and afterward by Say as *Tettigonia quadrivittata.*

The Hieroglyphic Leaf-Hopper.

(*Tettigonia hieroglyphica* Say.)

This was quite an abundant species the past season, but the majority of the specimens taken were found in the grasses of timber or among the low herbage along ravines, grassy banks, etc.

Professor Uhler says it "inhabits Texas, the foot-hills, and plains of Colorado from August to October, and the Atlantic region throughout." It is somewnat smaller than the *mollipes*, usually less than one-fourth of an inch in length; the head is rounded in front and marked with irregular black crescentic spots and bars. There is much variation in depth of coloring and extent of marking so that it is difficult to give a brief description that will be distinctive. While it was described in 1831 by Say, it has not been so abundant or noted as sufficiently destructive to get a place in the literature of economic entomology. Like many other of the species of this family, however, it has been lumped off with many of its relatives among the injurious leaf-hoppers, and hence should not be regarded as hitherto unmentioned among injurious species.

The Four-pointed Agallia.

(*Agallia quadripunctata* Prov.).

This species appears to be common throughout most of the United States, although I am not aware of its having been recorded as occurring in great abundance at any place. It is, however, one of the species which occurs in considerable numbers and does its share toward injuring the vegetation of pastures and meadows.

Whether it feeds mainly on grasses or attacks also the various plants growing with grasses I can not at present say, as it has not been studied in such connection as to determine this point.

It is about an eighth of an inch in length and of a yellowish-brown color with scarcely any decided markings except two black points on the front margin of the head and two similar points at the hind margin of the prothorax. These latter points are nearly in line with those on the head, though a little farther apart, so that the four points stand nearly at the corners of an imaginary square. Other points within the square are in some specimens quite distinct, but not so conspicuous as the ones described. The species appears to have been first described by M. Provancher (Nat. Can., IV, 376), in 1872, but it has quite generally been known among entomologists as *Agallia flaccida* Uhl. Mr. E. P. Van Duzee (Entom. Amer., V., p. 167) says:

> This species I have received in exchange from a number of correspondents as *Agallia flaccida* Uhler, and have so used the name myself in exchanging and in the *List of Muskota Hemiptera*. It seems to have been an early manuscript name of Mr. Uhler.

But little can be stated regarding the life history of this species and there are probably no important differences between this and other species of the same family. Nearly all the specimens taken or observed have been mature, and without rearing it would be uncertain whether larvæ apparently of this species really belonged to it. Adults have been taken at different times of the year, and probably it can be found in this condition during each month of the year. Mr. Van Duzee says in the article quoted above that "this is a very abundant species in western New York from early in May until September, and in fact the year round, as it appears to hibernate in the adult state, as do many if not all the *Jassidæ*."

I have not found it in grass during winter, and can not say whether it hibernates mainly in pastures and meadows or seeks the shelter of dead leaves and rubbish in thickets, hedges, etc.

Agallia sanguinolenta Prov.

This little Leaf-hopper has been quite common in this locality during the last few years, and while never so abundant that it can be counted a serious pest in itself it must be counted in with related species in any enumeration which pretends to give the grass-feeding species. That it has a wide range is indicated by the following from Professor Uhler (Bull. U. S. Geol. and Geog. Surv., vol. II, p. 359 [93, of part], 1876): "This is a very variable little insect, which is not confined to the region of the Rocky Mountains, but which has been found likewise in Texas, in British Columbia, Canada, and New England."

It was described under the name of *Bythoscopus sanguinolentus* by M. Provancher in 1872 (Naturaliste Canadien, IV, 376) and in 1876 by Professor Uhler under the name of *Bythoscopus siccifolius*. Mr. E. P. Van

Duzee has, however, in the Entomologica Americana (V., 166) placed this latter as a synonym, and remarks:

Through the kindness of M. Provancher I had the pleasure of examining a typical example of his species and have thus been able to compare it directly with Mr. Uhler's description, and find that it agrees in every particular. It is not an uncommon species here (Buffalo, N. Y.) on grass and weeds in pastures and road sides, especially where *Carex* and *Juncus* abound.

It is a little smaller than the *quadripunctata* and rather broader in proportion, and is quite readily distinguished from that species by the dark wing veins and the more decided markings on the head and prothorax. It is scarcely an eighth of an inch in length and fully one-third as wide as long.

A dark form which differs from the typical ones, so far as I can see, only in the greater intensity of the markings is perhaps even more common here than the typical form, and this I have found fairly plenty and quite active in blue-grass lawn during the latter part of November, so that we may be pretty certain that it hibernates under grass and probably feeds more or less during mild weather of late fall and early winter. It can also be considered as quite certain that it can live exclusively upon grass, as in the localities where I have observed it it could scarcely have been depending on other vegetation for its food.

The Wavy-Spotted Leaf-Hopper.

(*Allygus irroratus* Say.)

The propriety of including this species in a discussion of grass insects may possibly be questioned, since its range of food plants is very great. There is no question, however, that plants of the grass family are among those most commonly affected by it, and I have found it abundant in grass land, where evidently this was its only source of food. It will be unnecessary, however, to detail its method of work, as it agrees so nearly with other members of the same family, and all methods of treatment must be based on similar principles. It may be stated, however, that there is as yet no evidence, so far as I know, that it hibernates in grass, and therefore those remedies based on that habit in some of the species will not be applicable to this. Descriptions of the species were published by Say in 1831, and since that time the species has had frequent mention in entomological works, but only occasional reference to it as an injurious species is made, and in these references it is as often spoken of as a grain pest.

The Destructive Leaf-Hopper.

(*Cicadula exitiosa* Uhler.)

When attention was first called to this species it was from its attacks on wheat, but that it is of equal if not greater importance as a grass pest seems to me pretty clear after the observations of the present

season, and it would be interesting to know whether, in the reported destruction to wheat, this crop had not followed grass or whether the insects had not simply traveled from grass land. I have taken them in abundance from grass, and in blue-grass, where no other living plants were near, they occurred in large numbers, so that there would seem to be no question as to grass being their natural food. They have been reported as abundant and destructive on timothy in Missouri. (INSECT LIFE, Vol. I, p. 381).

They are about two-tenths of an inch in length, of a brownish color, and the wings are rather prominently marked with dark veins. It is an active species, jumps and flies readily, and is easily captured in a sweep-net, and would probably fall an easy victim to the "hopper dozer" or "shield," where these can be used.

It was described by Professor Uhler in the *American Entomologist*, Vol. III, p. 73 (1880), and a description and an account of its injuries to wheat in the Carolinas and Georgia occurs in the Report of the Department of Agriculture for 1879.

THE HURTFUL LEAF-HOPPER.

(*Jassus inimicus* Say.)

Of all the species of Homoptera that I have observed infesting grass this has been unquestionably the most abundant and constant in its depredations. It is *par excellence* a grass pest, and is found in great numbers in pastures and meadows at all seasons of the year, even in warm days of early winter, being found hopping actively about among the blades of grass and probably extracting some slight amount of food material even during this season. During the past season they have been especially numerous and destructive, or at least my attention has been called to them more frequently than before. My notes show them swarming in May, June, July, August, and September, and, recently, the latter part of November, and, later, December 12. I have found them scarcely less plentiful and active in the grass on blue-grass lawn. I observed them also in great numbers in all the pastures and meadows that I examined while in Linn County, in the eastern part of the State, in the latter part of June. Actual killing of grass by them is, however, a somewhat difficult matter to prove, and, except in seasons of unusual dryness, there is probably not sufficient withering of the grass from their presence to attract attention. In July and August grass here showed injury by turning brown in patches, and this commenced too soon after rains to be referred entirely to drought.

Later in the summer (September 7 and later), when the attacks of the leaf-hopper had caused most of the lawn to appear brown, such patches were not conspicuous. Examination of the grass where blades were not entirely withered would show in many cases brown spots of varying sizes, generally with the center on or near the midrib, and from small

spots of this kind all gradations of withering could be found up to where the entire blade was withered or brown. Plenty of these insects were to be found even where the grass was comparatively dry, but that they preferred the more juicy grass was shown by their accumulation in shaded places or where the grass presented more vigorous aspect. They could be secured in abundance from patches where no other vegetation occurred, and in the absence of other insects in numbers to cause the withering mentioned, there can be no question, I think, as to the serious nature of their attacks upon the grass. Even when they do not cause withering of grass they must draw seriously upon its vitality.

I have thus far been unable to separate any definite broods. Adults occur during the entire year, and larvæ, which may be quite certainly referred to this species, may be found associated with them during the most of the summer months. Larvæ are perhaps most common during June and in August and September, but whether there are two broods or three, or an indefinite number depending only on the length of the season, I can not now say. It seems most probable, however, that breeding goes on irregularly all through the summer months, but that the adults of spring are represented by only two or three generations of progeny, and the members of the latest broods survive the winter to begin the production of new generations in the spring.

In connection with his description of the species, which was published in 1831, Say makes the remark that "When in the larva state this species is said to depredate on the roots of wheat. Several specimens were sent me by Professor Green in the year 1822, who received them from a farmer in Virginia."

Considering the wide distribution and great abundance of this species, it seems strange that it should have been so little studied or so rarely mentioned in works on injurious insects.

The insect is somewhat less than a fourth of an inch long and appears grayish or yellowish gray, and about the most constant marking are two dots on the front of the head, two on prothorax, and two on scutellum. A form lighter than the typical examples but which seems to me only a light variety, has even these dots obscure or wanting.

The larvæ are light yellowish but seem to be subject to about as much variation as the adults. An extreme form of larvæ, probably belonging to this species, has dark margins to the prothorax and abdomen.

Several other species of *Jassidæ* have been observed in grass, but as they are not as yet determined I omit further mention of them at this time.

THE GRASS-ROOT PLANT-LOUSE ALIAS THE DOGWOOD PLANT-LOUSE.

(*Schizoneura corni* Fab.)

Probably the most interesting result of my season's observations from a scientific stand-point, and it may be the most important economically, is the determination of the identity of a form of plant-louse in-

festing the roots of grasses during the summer with one occurring on the leaves of dogwood during autumn. The full import of this connection from the economic stand-point can not be known till it is determined how many species of grasses are affected by the root form and to what extent the migration to dogwood exposes it to attack. If its occurrence is confined to the annual grasses (and it seems to occur only on these), its importance to the farmer will be much less than if it is found to work also on perennial species.

A brief statement of the connection between these two forms was published in INSECT LIFE (Vol. II, pp. 108–9), but a fuller account, with details of observations, is proper at this time.

My attention was first called to this species on September 15, when I noticed the air was filled with small insects, which on capture were found to be plant-lice of the genus *Schizoneura*. Their immense numbers, filling the air as far as could be seen in all directions, naturally excited my interest, and I walked some distance in the direction from which they seemed mainly to come (which was with the wind), but without locating their origin, except to observe that they were resting on all sorts of plants and were very plentiful along roads and paths where fox-tail and other grasses were plenty. Upon examination I determined the specimens gathered to be *Schizoneura corni* Fab., specimens of which I had gathered a year or two ago from dogwood. It seemed difficult, however, to account for such an immense swarm of them when dogwood is not especially abundant in the immediate vicinity and had not been observed as infested with aphids. In looking over descriptions of allied species I was struck by the close agreement with descriptions of *Schizoneura panicola* Thos., and, following this lead, I examined the roots of *Setaria* and *Panicum* on September 16, when the winged forms were again numerous in the air. My search was almost immediately rewarded with the finding of numerous wingless *Schizoneuræ*, and among them some which showed wing-pads and two with wings partly expanded. These were compared carefully with winged *corni* found flying and also with *corni* from dogwood, and showed such close agreement that I felt it important to follow the matter up. One of the specimens, with wings partly developed, was mounted in balsam for future reference; the others, on grass roots, were put in breeding jars. Their subsequent history will be stated later on.

Examinations in the field on the 18th showed lice still somewhat plenty on grass roots, though the *Setaria* examined failed to show them in very great abundance. Examinations the same day, of the dogwood in the timber near, showed on the very first bush noticed numbers of the winged (*pseudogyne*) individuals, and with them numbers of small larvæ evidently just extruded. The colonies accompanying each *pseudogyne* contained from one to a number of larvæ, but none of these could have been more than a day or two old, all very small, scarcely larger than when first born. In no case could I find a leaf on any of

the bushes examined which contained any colonies without the winged mother or where there was the slightest evidence of the previous presence of aphides; no cast skins from old colonies or damaged leaves, and every indication went to prove that the winged form had just settled upon the trees and begun the formation of colonies. While perhaps of little value as proof, it may also be mentioned that no Schizoneuræ had been observed on *Cornus* this fall prior to this date or before the swarming of September 15. A number of branches containing colonies were brought in and kept in water for the purpose of following their development. This was fortunate, as the colonies on the plants out of doors were almost all depopulated a few days later by predaceous insects, so much so that the colonies on plants near at hand and on which I depended for following the species out of doors utterly failed to furnish material for that purpose. Indoors the insects developed rapidly and were followed as closely as circumstances would permit. Molting in these occurred by the 19th, and apparently only one molt occurred before maturity. Only one brood was developed, these becoming sexually mature September 25. Both males and females were apterous and copulation took place upon the leaves and also upon the twigs, the females often traveling down the twigs and branches while copulation was in progress. In every case the females seemed to travel down the branches as far as possible before depositing eggs, and great numbers of them dropped into the water in which the branches were kept. In the woods I have been unable to find any eggs whatever under buds on twigs, and so far as the indoor observations go they differ from those recorded by Mr. Weed. Whether this be due to dryness, the insects seeking a place of some degree of moisture, can be determined by comparisons under varying conditions.

Two weeks after the swarming of winged lice in the air there was another swarming, though the lice were not so numerous as at the first time. This swarming also followed a rain with subsequent cold. As in the preceding case, examination of *Cornus* in the woods showed numerous winged individuals starting colonies, though at this time in some places it was possible to find the cast skins of previous colonies, all of which, however, so far as I could find, had been destroyed by predaceous insects or other causes. My search for eggs in the woods has been futile, and it would seem that nearly all the colonies were destroyed before the maturity of the sexual individuals. I have found, however, oval bodies a trifle larger than the eggs, but resembling them at first sight, though flattened, but which prove to be a small species of *Lecanium*, apparently undescribed.

The lice occurring on the roots of grass, and which were placed in breeding jar the 16th, were mostly unaltered on the 19th, but in the jar I found a fully winged specimen, agreeing exactly, so far as could be seen with hand lens, in the living individual, with specimens flying and also with those on *Cornus*. It was transferred to a leaf of *Cornus* on

twig inserted in water, isolated from other leaves, and which had been carefully examined with lens to see that it was free from larvæ, and protected by cheese-cloth cover. This individual took kindly to the situation, remained constantly on the leaf, and produced a number of larvæ which developed as rapidly as those brought from the woods, agreeing perfectly with them in every particular that I could observe, and proving their ability to develop on *Cornus*. Unfortunately their propensity for traveling down the twigs resulted in their being drowned in the water in which the twig was kept. I think, however, that their developing perfectly on the Cornus leaf, and the perfect agreement of apterous males and females so developed with those occurring normally on *Cornus* in woods, is good evidence of identity.

In the meantime lice had been found in some numbers on the roots of grasses not yet dead, especially on *Panicum*, and many of these had been placed in breeding-jars in hopes of securing additional winged specimens. While apparently thriving they failed to acquire wings, but on September 24 I observed in one of the jars an apterous individual, and directly behind it an egg evidently fresh-laid, elongate, oval, greenish, polished, like eggs of *corni* on *Cornus*. This was mounted with the apterous individual, and in the body of the latter another egg was apparent. The egg was laid at the surface of the earth in the jar, and similar eggs were found in pill-boxes in which root-lice were confined. A close examination of roots, especially those of *Panicum* from the field, enabled me to find a number of small apterous individuals like the males on Cornus leaves, as well as the small apterous and oviparous females. These occurred with a larger form, exactly like those which had been observed to acquire wings, and the conclusion seemed inevitable that these viviparous and apterous forms produced in the ground a brood of apterous males and females. These latter were observed attempting coition, though in no case did I see the act completed. The males are of an orange color, darker than the females, and differ from males on Cornus leaves in being shorter, and in lacking the purplish tint usually present in those. The females agree well with females on Cornus leaves, but are shorter, have *six-jointed* antennæ, and are slightly lighter colored, which would be expected in individuals living under-ground. September 28, eggs from these root-forms were more numerous, and by October 3 I found them quite plenty in my jars. One oviparous female was observed with three eggs extruded from the body, adhering by the ends, and the last one still partly within the body. They are whitish at first, but turn yellow on exposure, and later turn quite dark.

The eggs seem to be deposited at hap-hazard on surface of earth, sides of boxes or jars, and each female appears to produce but two or three eggs.

These observations, I am free to confess, appear to complicate the round of life of the species, and to make the complete circle from grass

to dogwood and back less clearly defined, but such a dimorphism, if we may call it so, is not without parallel, and does not seem unreasonable. There seems reason to believe that while a large proportion of the *pseudogynes* acquire wings of perfect development, and migrate to dogwood, that there is also another portion in which the wings for some reason fail to develop, and these from necessity remain on the roots or at best remain near the surface of the ground, and the sexual generation produced by them at the same time as from the winged ones, or perhaps a little later develop by feeding upon grass roots, and deposit their eggs where they have themselves developed. As to whether these eggs are as successful in their further development as the ones deposited on *Cornus* remains for further observations to determine. Possibly in certain seasons they may survive better, and thus provide a double means for the preservation of the species. As to the conditions which might affect the acquisition of wings we can do little more than speculate, but it seems proper to call attention to the possible elements that may furnish a solution.

The day before the first swarming of *Schizoneura* (14th) had been very warm in the middle of the day, with a heavy shower in the latter part of the afternoon, followed by a steady rain in the fore part of the night, and this by a sharp fall in temperature, so that the morning of the 15th was clear and cold (possibly a slight frost). The day remained cold, but was bright and sunny, and the swarming observed occurred in the latter part of the afternoon. Some other aphids were observed on the wing, but very few as compared with the swarms of *corni*. *S. corni* was seen in the air on subsequent days, but comparatively scarce till, again two weeks later (29th), after a very similar condition of weather (warm, with rain, followed by cold), when another swarming occurred. Now, it may be that those individuals, which are at a certain stage when such conditions occur, are enabled to acquire wings while those less fully developed remain without the full expansion of these appendages.

In comparing the two forms infesting grass roots and dogwood, respectively, I have studied great numbers of wingless individuals, winged forms and apterous males and females, and have come to the conclusion that they must all belong to the same species. It will, however, be in place, I think, to place in position for comparison the different descriptions which have been given of the species to show that, notwithstanding the terms used by different authors, and their wide separation in time and place, there is no real discrepancy in them. The original description by Fabricius is very short and general, and is as follows (Ent. Syst., IV, p. 214, No. 19):

Corni. A. Corni sanguineæ.

Habitat in Corni sanguineæ foliis.

Corpus nigrum abdomine basi et subtus virescente. Pedes nigri. Anus absque stylo et corniculis.

Juniores pallidi macula magna, dorsali, nigra.

Passerini, in Gli Afidi (1860), describes the root form as follows :

Schizoneura venusta, m.

Femina vivipara aptera ovata-convexa, pallide viridis, vel interdum rubella; capite, fasciis dorsalibus anticis tribus, macula discoidali quadrata, fasciis posticis duabus, punctisque marginalibus nigris. Rostrum crura media attingens. Long., 1‴.

Femina vivipara alata capite et thorace nigris. Abdomen viridi luteolum vel rubellum, vittis transversis anticis duabus, macula discoidali subrotunda, fasciis duabus posticis, punctisque marginalibus nigris. Nectaria tuberculiformia, nigra. Alæ hyalinæ, venis stigmateque nigris. Long., $\frac{3}{4}$‴, 1‴.

Nympha lutea, capite et thorace pulverulentis.

Turmatim in radicibus Setariæ viridis, S. glaucæ, S. italicæ, Panici glabri, Eragrostidis megastachyæ et Ceratochloæ australis. Autumno.

Valde similis *Schizoneuræ corni*, quæ autem diversa dorso omnino nigro in apteris, et abdominæ basi et apice tantum albido in alatis.

Thomas gives a translation in his work on Aphidæ, which reads:

Schizoneura venusta Pass.

Wingless female.—Ovate convex, pale green, and sometimes reddish; head, three anterior dorsal fasciæ, a quadrate discoidal spot, two posterior fasciæ and marginal points, black. Rostrum extending about to the middle legs. Length (of body), 1^{mm}.

Winged female.—Head and thorax black. Abdomen, greenish-red or yellowish; two anterior fasciæ, a subrotund discoidal spot and marginal points, black. Nectaries tuberculiform and black. Length, $\frac{2}{4}$ to 1^{mm}.

Pupa, yellowish, head and thorax pulverulent. Found on roots of *Setaria viridis*, *S. glauca*, *S. italica*, *Panicum glabrum*, *Eragrostis megastachya* and *Ceratochloa australis* in autumn.

This translation is incomplete and imperfect, especially in the dimensions, which are given as millimeters instead of lines (twelfths of an inch), which would lead one to suppose them about half the actual size. So far as I can see, Passerini's original description is entirely applicable to the specimens obtained from roots of grasses here as well as to fresh specimens of *corni* on *Cornus* leaves.

Walsh published the following descriptions (in 1862) in the Proceedings of the Entomological Society of Philadelphia, Vol. I, p. 304.

Eriosoma ? fungicola n. sp.

From recent specimens. Body black, with a plumb-like bloom; basal half of abdomen and whole of venter yellow. Antennae and legs black. Wings hyaline with a dusky tinge; veins dusky, black on the basal half of the costa; third discoidal hyaline nearly to its fork, stigma palish brown. Numerous individuals unaccompanied by larvæ, occurred on a large moist fungus a hundred yards from the nearest trees, which were all oaks. Beat solitary individuals unaccompanied by larvæ or woolly matter, on two separate occasions from oaks, which, when dried, differ only from the dried specimen of those found on fungus by the metathorax being varied with pale greenish, as well as the base of the abdomen. Length to tip of wings .12 to .13 inch.

The antennæ do not quite attain the base of the first discoidal when the wings are expanded, and the stigma is rather more than twice as long as wide. Six specimens in all. *E. querci* Fitch is larger (.16 inch) and is entirely black. Differs also from the other described United States species.

Eriosoma? cornicola, n. sp.

Differs from the preceding only in the body being entirely black. Numerous individuals, unaccompanied by any flocculent matter, and so far as I recollect by larvæ, occurred in September on the lower side of the leaves of the Red osier dogwood. Ten specimens.

Dr. Thomas, in repeating these descriptions in the "Aphididæ" (8th Report State Entomologist of Illinois, pp. 141, 142), separates the two by *Schizoneura caryæ* Fitch, so that "Differs from preceding only," etc., refers to *caryæ* and not to *fungicola*. This circumstance is liable to mislead, unless Walsh's original descriptions are at hand for reference, and may account for the uncertainties that have been stated in efforts to determine Walsh's *cornicola* found on *Cornus*.

Considering that *fungicola* was on a fungus, a plant never known to support Aphides, and that the difference noted by Walsh is such as results from greater maturity of specimens that have located on *Cornus*, and further, that *fungicola* agrees perfectly with both descriptions of *corni* and with fresh individuals found on *Cornus* leaves, it seems pretty certain that these two descriptions refer to one and the same species.

Thomas' description of *S. panicola*, published in 1879 (8th Report, State Entom., Illinois, p. 138), is as follows, and is said to have been written from recent alcoholic specimens:

Winged female.—The front wings with the third discoidal veins once forked; third vein obsolete at base; first and second veins arising very near each other; stigma short, rounded behind; fourth vein nearly straight; costal bent outward to the base, leaving a rather wide space between it and the subcostal; antennæ short, reaching about to the base of the fore wing; slightly hairy; third joint rather longer than the fourth and fifth united; sixth slightly longer than the fifth, with a very short, indistinct, blunt spur at the tip; beak rather long, reaching nearly to the hind coxæ, slightly hairy; eyes present and of the usual size or nearly so.

Wingless female.—(Probably not fully developed.) Very broadly ovate and very convex, being suborbicular; antennæ, reaching about to the end of the thorax, rather thick and heavy and not tapering to apical joints, if any difference rather thicker than the middle ones; third joint longest but not quite equal to the fourth and fifth united; fifth rather longer than the fourth, gibbous on one side at the tip; sixth nearly as long as the third; beak, long, reaching fully to the hind coxæ; color of the alcoholic specimens, reddish-yellow; eyes minute and black.

Found on the roots of *Panicum glabrum* and other grasses by H. [Th.?] Pergande at St. Louis, Mo., in November.

The difference in the length of the beak will certainly distinguish this from *Tychea panici*, even supposing the antennæ in the latter to be undeveloped.

Mr. O. W. Oestlund, in Synopsis of the Aphididæ of Minnesota (Bull. No. 4, Geol. and Nat. Hist. Surv. of Minn.) describes both *corni* and *panicola*, and their identity could not be more strikingly indicated.

S. corni.

Head and thorax black; abdomen reddish-black, with a large patch of velvety black covering all of the dorsum except three and some of the last segments. Antennæ reaching to the end of thorax; not annulated, hairy, with a single row of circular sensoria on the under side, about six to the third joint, three to the fourth, two to the fifth, and one at the contraction of the sixth; III, 0.30^{mm}; IV, 0.12^{mm}; V, 0.10^{mm}; VI, 0.15^{mm}, with the short unguis. Beak reaching third coxa. Wings hyaline, with slender veins; cubital obsolete at base; stigma broad and short, smoky. Honey tubes a circular opening almost on a level with the abdomen. Expanse of wings, 6–7^{mm}.

S. panicola.

Head and thorax dusky or black; abdomen pale greenish with some black marking above, on the last segment at least. Antennæ reaching to the end of the thorax,

hairy, third joint the longest, the following subequal; sensoria rather indistinct, three or four to the third joint, and usually one or two to each of the following. Beak reaching abdomen. Honey tubes as circular openings on level of surface of abdomen, but rather conspicuous from being bordered with a ring of black. Wings hyaline with slender but distinct veins. Fore wings with the cubital obsolete for some distance at base; stigma short and broad; stigmal vein but slightly curved near the base, straight. Expanse of wings, about 5mm.

Careful descriptions of the different forms on *Cornus* are given by Mr. Clarence M. Weed (Psyche, V, p. 129), the species being referred doubtfully to *cornicola* Walsh.

Winged viviparous female (*pseudogyna pupifera*).—Expanse of wings, 6mm; length of body, 2mm; width of body, .80mm; length of antennæ, .90mm.

Black above, except anterior and lateral margins of abdomen, and in many specimens more or less of posterior portion. Beneath black, except prothorax and abdomen (save a black patch in front of anus), which are dull whitish-brown. Rostrum black, except a more or less distinct lighter patch near base, hairy, reaching posterior coxæ. Legs robust, black, except a short brownish space at base of anterior femora; thickly provided with brown hairs. Antennæ robust, beset with brown hairs. Joints I and II, short, smooth; III, long, with row of tubercles on its outer ventro-lateral surface; IV and V subequal, with tubercles as on III; VI, a little longer than V, excavated on its outer lateral surface about two-thirds distance from base. Wing veins mostly brown. Stigma brownish, with interior portion darker.

Described from many specimens taken October 24, 1887, on leaves of *Cornus sanguinea* and *C. sericea*, where for some time previous they had been very numerous, founding sexed colonies. Usually occurring on the under surface.

Apterous male.—Width of body, 0.50mm; length of body, 0.89mm; length of antennæ, 0.47mm.

Body and members brownish or brownish-black, with numerous brown hairs. Eyes black. Body flattened, long and narrow, with nearly parallel sides. Antennæ half as long as body. Joint I, short, swollen; II, small; III, longest; IV and V, subequal; the latter excavated on its apical lateral surface. Legs long, robust, same color as body. Rostrum robust, reaching anterior margin of posterior coxæ.

Described from several living specimens (part taken *in copula*) from *Cornus sericea*, collected October 24, 1887.

Oviparous female.—Width of body, 0.50mm; length of body, 1.14mm; length of antennæ, 0.35mm.

Green, or greenish-brown, slightly darker anteriorly. Shape, elongate oval; sparsely clothed with brown hairs. Eyes blackish. Antennæ green, slightly darker apically; joint III longest, V slightly swollen in middle. Rostrum robust, green, darker at tip, reaching anterior margin of posterior coxæ. Legs unicolorous with body, dusky apically.

Egg.—Elongate oval, 0.56mm long, 0.20mm wide.

Green at first, becoming black by exposure. Deposited on bark, in and about the axils of buds and small branches.

Described from many specimens on *Cornus sericea*, October 24, 1887.

These descriptions are so full that I deem it unnecessary to draw up another. I may mention, however, that the apterous males usually have what I should call a purplish tint with the brownish color when alive, due, perhaps, entirely to the delicate bloom covering them.

The most distinctive character of *corni* is perhaps the hairy antennæ and the six or seven circular sensoria on underside of the third antennal joint. The number of these sensoria varies slightly, but in the form I

reared from grass roots and allowed to colonize on Cornus leaf there are the full number common to *corni* and show distinctly. Mr. Oestlund's statement that they are indistinct and but three or four in number might, I think, apply to an extreme variation or to specimens fresh from the ground. The dark spot on the dorsum of the abdomen is not only variable in size but differs much in appearance with the age of the specimen and in dead or preserved specimens. While I am free to admit some puzzling questions, I am strongly convinced of the main point here claimed. There is certainly much more of interest to be learned regarding the species. I feel that only a beginning has been made, and shall watch eagerly for further developments. As the Aphides are so uncertain in their appearances and can not be depended upon to furnish material in abundance in every locality, it will add to the certainty of completing the history of this species if entomologists in various localities will make such observations as possible the coming season.

If my conclusions are correct the synonomy for this species will read as follows:

(1794) *Aphis corni* Fabricius, Ent. Syst., IV, 214.
(1860) *Schizoneura venusta* Passerini, Gli Afidi, p. 38.
(1862) *Eriosoma? fungicola* Walsh, Proc. Ent. Soc. Phila., I, 304.
(1862) *Eriosoma? cornicola* Walsh, Proc. Ent. Soc. Phila., I, 304.
(1879) *Schizoneura panicola* Thos., 8th Rep. Ill. Ent., p. 138.

SUMMARY.

Schizoneuræ abundant on grass roots and assuming winged form in latter part of September (15–28) and on several days during this time the air was filled with like insects, and immediately following these flights apparently identical Aphides were colonizing on leaves of dogwood, which had hitherto been free from them.

Schizoneura (winged *pseudogyne*) reared from grass roots and transferred to leaves of *Cornus* established colonies apparently identical with those occurring normally on *Cornus*.

Schizoneura (apterous individuals) in some number remain on grass roots and are associated with apterous males and females, the females of which are oviparous.

Individuals of these different forms agree with each other and with descriptions of both *corni* and *panicola* and differences do not exceed the range of variation common to species of Aphididæ.

CONCLUSION.

Taking all these facts into consideration, I believe that the species of *Schizoneura* infesting grass roots and dogwood leaves and described as distinct species are identical.

That the winged generation of asexual individuals produced from grass roots in autumn migrate to leaves of dogwood of different species and establish colonies of apterous individuals, which become sexually mature and the females of which deposit eggs on dogwood.

That the number of broods produced on *Cornus* in spring (which must now be inferred) and the time of return migration to grass are yet to be determined.

That in addition to the migratory winged autumn brood there appears to exist under certain conditions an apterous form which produces a brood of sexual individuals on grass roots the females of which deposit eggs the fate of which is unknown.

HETEROPTERA INFESTING GRASS.

The Chinch Bug.

(*Blissus leucopterus* Say.)

The Chinch Bug is too well known as a grass and grain pest to need any special mention in this connection. It may be noted, however, that it prefers the annual grasses rather than perennials, and were it confined to the noxious Foxtails (Setaria) we might have no reason to complain, but its fondness for Hungarian grass is too conspicuous to pass over. It does not appear to multiply as rapidly in sod land, though I have found it in Blue-grass where this alone could furnish it food.

The Long Bug.

(*Ischnodemus falicus* Say.)

Were it not for its elongated form this species could be most easily mistaken for the Chinch Bug, for, excepting this peculiarity, it comes nearer in appearance to the Chinch Bug than any of the numerous species which have been confused with that noted pest.

Hitherto I believe it has not been classed among insects of economic importance. It is, however, quite evidently increasing in numbers in this region and should, I think, be mentioned, at least, in this connection. That it is a grass-feeding insect is evidenced by its abundance in all stages in grass land where other plants are scarce or wanting, and would be expected of an insect so closely related to the Chinch Bug. I have found it more common in rather low ground, and especially in the wild grasses between upland and bottom-land, or along the borders of sloughs or small streams.

While only a fall brood of larvæ, developing in July and August and maturing in September, have as yet been observed, it is probable that, as with the Chinch-Bug, there are two broods each year, adults of the second hibernating and depositing eggs in the spring.

If multiplying, so as to become a serious pest, I know of no remedies to suggest further than those applicable to Chinch Bugs, and probably the most efficient one would be that of burning dead grass and rubbish in the fall.

There are several other species of the Heteropterous Hemiptera, notably certain *Capsidæ* such as *Miris affinis* and related species, and several species of *Lygus*, which I suspect will be added to our list of grass pests, but I have as yet made no careful study of their habits.

REPORT OF OBSERVATIONS UPON INSECTS AFFECTING GRAINS.

By F. M. Webster, *Special Agent.*

LETTER OF SUBMITTAL.

La Fayette, Ind., *December* 14, 1889.

Sir: I herewith transmit my annual report of observations on insects affecting cereal grains, made under your direction, during the current year. A more elaborate report, treating of the destructive grain insects of the United States, to be prepared jointly with yourself, is nearing completion, and the present report is submitted now, in order to avoid the necessity of including details in the more important work to follow. As usual, I am under many obligations for the determination of specimens and numberless other courtesies.

Respectfully submitted.

F. M. Webster.

Prof. C. V. Riley,
U. S. Entomologist.

THE WHEAT STRAW WORM.

(*Isosoma tritici* Riley.)

These insects have not been observed by me in any great numbers since they were last treated in my reports, and the species is only mentioned in order to record the occurrence of a female of the wingless spring form, on the 18th of July, in a field of wheat.

THE WHEAT STEM MAGGOT.

(*Meromyza americana* Fitch.)

Since the establishment of the fact of a summer brood originating during the month of August, and largely, it is supposed, in volunteer wheat, considerable emphasis has been placed upon the destruction of this illegitimate growth of grain. There has, however, been pretty good cause for believing that the insect developed also in other plants, and this season we have reared the adult from Blue grass, *Poa pratensis*, during the latter part of August.

Since the discovery of the species there has been nothing placed on record relative to its discrimination between varieties of wheat, or

whether these insects really possessed any such instincts, the inference having been that one variety was as acceptable to them as another. Bearing upon this point I have obtained some interesting information, which, though by far too slender a thread on which to hang a positive assertion, yet forms sufficient grounds for a suspicion that the species may possess some exceedingly fine instincts regarding plant tissue.

In the month of September, 1888, a field of oat stubble on the experiment farm was subdivided, two plats each several acres in extent being sown, the one to velvet chaff and the other to Michigan Amber wheat. Between the two was a narrow strip comprising a mixture of both varieties. From the beginning of preparation of the ground to the end of harvest this year all conditions excepting seed were exactly the same.

The attacks of these larvæ were quite severe during June, and on the 14th of this month an examination of the plats above mentioned developed the fact that in the velvet chaff the destroyed heads outnumbered those in the Michigan Amber in the proportion of about four to one. Furthermore, the narrow strip of mixed grain intervening showed very much the same feature. I confess that I am unable to detect any reason for this difference in the severity of the attack other than in the nature of the straw; that of the velvet chaff being under ordinary conditions a few days earlier in maturing, yet it is known among farmers as possessing a softer straw than the Michigan Amber, which fact presupposes the tissue of the stem immediately above the upper joint to be to a corresponding degree more tender and juicy at the time of oviposition by the females.

THE WESTERN STRIPED CUTWORM.

(*Agrotis herilis* Grote.)

The present year has been conspicuous for the severity of cutworm attacks, especially in corn-fields, the most abundant and pernicious species thus engaged being the one under consideration. Ordinarily we look for these dusky, semi-subterranean destroyers in fields of recently broken grass lands, but this season their ravages were not to be limited by any such proscribed bounds, and old lands suffered with the new.

On the 28th of May I visited a field of corn a few miles out of the city of La Fayette, which had been nearly ruined by cutworms, notwithstanding the present was the seventh consecutive crop of corn which had been planted on this ground. In fact, so abundant were the pests, that from a mass of dried weeds and earth, covering a couple of square feet, and which had been left by the plows, I took 36 individuals, and a clod a few inches away concealed 5 more; the whole number evidently belonging to the same species.

The only apparent cause for this congregating in corn-fields, and in this one in particular, is that during the ovipositing season last sum-

mer the grass lands in this section were withering and drying up under a terrible drought. This corn-field had been poorly cultivated and the lower portions grew up to grass and weeds, thereby forming a more desirable locality for the females to lay their eggs. In other words, the drought of August and September of 1888 drove the moths to the corn-fields to oviposit, and the abundance of worms this year is the result.

The thirty-six cutworms collected on May 28 were taken home and immediately placed in a breeding cage, being fed upon clover during the few days they remained above ground. The first moth appeared on August 23, followed by others up to the 26th, when a medium-sized *Anthrax* was also observed in the cage. As nothing could be found in the literature at hand to indicate that any of the *Bombyliidæ* had ever been reared from lepidopterous larvæ, in this country, its occurrence was supposed to be accidental, the larva having been in some way taken up with the earth in the cage. It was followed, however, on September 1 by a second adult, and two more appeared on the 4th, others appearing up to the 9th, when all doubts as to the host of these flies were removed by two adults issuing from a couple of chrysalids laying on the surface of the soil, the *Anthrax* leaving their empty pupa cases protruding half way out from the chrysalids of the *Agrotis*. The flies may be roughly described as from 10 to 13^{mm} in length, black, densely covered with fine silky hairs, those on præscutum and episternum of mesothorax, basal half of abdomen, and tuft on posterior margin of penultimate segment being silvery white, changing to yellowish, especially on the shoulders.

The same species was frequently observed, near the middle of September, hovering about over the surface of the ground under trees recently denuded of their foliage by the larvæ of *Datana ministra*, thereby conveying the impression that they might be parasitic upon that species also.

As nothing whatever is known of the time and method of oviposition of the *Bombyliidæ*, it will only be safe to say that the eggs were deposited either on or about the bodies of these cutworms prior to the 28th of May.

In a most excellent paper by Dr. Riley, in the Second Report U. S. Entomological Commission, pp. 262–269, larvæ of an allied species is mentioned as infesting the egg-pods of *Caloptenus spretus*, being found of different sizes during most of the year. From rearing this species, *Systœchus oreas*, O. S., Dr. Riley concludes that, "as a rule, but one year is required for full development;" but there is great irregularity and a tendency to retardation of such development.

Should the species under consideration be of similar habits, the eggs would, as a matter of necessity, have been deposited last fall, the larvæ wintering over in the bodies of these cutworms, which are not usually over half grown at the beginning of winter. If this be true it is certainly an interesting feature of parasitism.

THE ARMY WORM.

(*Leucania unipuncta* Haw.)

With the rapidly increasing area of low, wet lands, which are being under-drained and brought into cultivation, the natural haunts of this species becomes more and more encroached upon. What the ultimate effect of this change of natural conditions will amount to in the future, and whether or not it will have a tendency to scatter the spring brood of moths in their selection of places of oviposition, only future years will answer. In accordance with the characteristic partiality of the species for low, damp localities, the outbreaks in Indiana this year have been restricted to the lower laying and flatter portions of the State, where a very considerable part of the land remains undrained, except by open ditches. While this state of affairs has been going on, the fact that dry seasons are favorable to the increase of the species has been amply demonstrated. The last two summers have been unusually dry, and the spring of the present year, up to May 30, was exceedingly dry, making three consecutive years of drought, during all of which this pest has appeared in various portions of the State, the maximum injury being caused the present summer. During this period, also, we have had wet springs and dry summers and dry springs and wet summers, proving conclusively that wet weather has little if any direct influence upon the increase or decrease of numbers. In short, it is difficult to resist the suspicion that this ebb and flow, so to speak, may be due more to the fluctuation of natural enemies than to the direct influence of meteorological conditions, severe droughts excepted.

In the vicinity of Princeton, Ind., where considerable damage was done last year, there occurred this season only one weak, aborted outbreak, in a small field of rank growing timothy grass. A slight attack three years ago on the borders of a large tract of swampy land in the vicinity of La Porte, Ind., was not followed by others, either last season or this, although this year similar and more serious outbreaks occurred in that immediate section of the State, and within a few miles of the same locality. Such phenomena can not be wholly attributed to meteorological conditions, most certainly. The most efficient parasites of the army-worm are two species of *Tachinæ*, and we have reared both plentifully this season. The local effects of these parasites is probably more lasting than we are given to suppose. A circumstance came under our observation recently where the attack of a similar species of *Tachina* on the larvæ of *Datana ministra*, infesting an isolated walnut tree, was such that the tree has been free of the caterpillars since 1885. If the effects are equally lasting in the case of the army-worm it will be difficult to foretell their appearance in dangerous localities, even in seasons supposed to be most favorable.

Again, the secret of the power of the army-worm to destroy is in their massing together in endless numbers. Were it not for this they would

not be more destructive than others of the group of cut-worms to which they belong. As stated in the beginning, the prevailing system of underdrainage has at present a tendency to emphasize this gregarious habit by restricting the area of wet grounds.

Whether this will continue to be the case, or whether, after a time, the effect will be to break up the habit of massing into large swarms, and diffuse them into smaller and less destructive colonies, remains yet to be seen.

The heaviest damage has this season, here in Indiana, fallen upon the rye crop, a state of affairs which has excited much comment among farmers. The reasons for this seemingly general selection of this crop, for depredation by the worms, are (1) on account of its hardy nature, rye is often sown on these swampy or mucky lands, as it withstands the weather there better than any other crop; and (2) by nature it is a rank grower, and, therefore, a field in spring presents to the female moth all the requirements of a suitable locality to place her eggs, viz, where her progeny will have an abundant supply of succulent food, in a damp place and shaded from the direct rays of the sun. In all fields of rye examined which have been ravaged by the army-worm, the latter were found to have originated in the fields themselves and had not migrated to them. Cases were not uncommon, however, where the worms originated in grass lands and from thence invaded fields of wheat and oats.

The prospect of controlling the outbreaks of the army-worm in the future seems encouraging, provided the farmer is perfectly familiar with their habits. Much of the damage done might be prevented if decided measures were taken at the start. The trouble is that too often the farmer wastes the most precious time in waiting to see what the worms are going to do, and by the time he finds out they are beyond control.

So far as I have been able to learn, where a neighborhood has turned out *en masse*, and taken decisive measures to destroy the worms, little injury has been done. These measures have consisted in ditching around the infested area and either flooding the ditch with water, or otherwise destroying what fell into it, and driving stock over the area inclosed by the ditches, whereby vast numbers of worms were crushed. From pupæ obtained in Fulton County the following parasites were reared: *Ichneumon brevicinctor* Say, *Nemorœa leucaniæ* and *Drymeia* sp?. *Ophion purgatus* Say, also a parasite on *Leucania*, was this year reared from pupa of *Scoliopteryx libatrix.*

THE FALL ARMY-WORM.

(*Laphygma frugiperda* Ab. and Sm.)

In 1885 and again 1889, we found larvæ of this species feeding on the tassels and unfolding leaves of young volunteer corn, late in September, in the vicinity of La Fayette, Ind. In both cases we reared adult

moths from the larvæ, the former appearing during late October. These breedings would seem to indicate that at least some of the fall brood may winter over in the adult stage.

A NEW CUT-WORM.

(*Luperina* (*Hadena*) *stipata* Morr.)

On May 28, while searching for Sphenophorus in a field of corn planted on recently broken prairie sod, a depredator was found which both in itself and method of work was new to me. Though the young corn was at the time several inches high, many of the plants were withering and dying, but aside from this neither the plant itself nor the earth about it gave the least indication of the presence or nature of the destroyer. Digging down in the earth about the hills, one or more of the shoots would be found wholly or partly eaten off, either near or a short distance above the seed, and in a single instance the seed kernel itself was observed being eaten. The method of attack appeared to be to first eat into the tender stem and then to burrow upward, after the manner of *Gortyna nitela*, above ground, and as soon as one plant was consumed another was attacked, without the worm coming to the surface. The larvæ were rather slender, from half to three-fourths of an inch long, quite active and in general coloration somewhat resembling the larvæ of *Crambus zeellus*, but being more robust, spinning no web and living wholly under ground. Larvæ taken from the field June 8, continued feeding in confinement until early in July, and the moths appeared in the breeding cage about the 25th of the same month. On account of being absent from home much of the time between the middle of June and 20th of July, it was impossible for me to get exact dates.

My own collections of larvæ were from recently broken prairie sod only, none being found in timothy or blue-grass sod adjoining. Farmers in the vicinity of this field state, however, that the worm does work in timothy sod, and serious damage in a fall-plowed field was attributed to their work.

Under date of June 15, Mr. J. C. Besom, of Anderson, Madison County, Ind., wrote me that a kind of Cut-worm had appeared in his fields which he had never observed before. They began working on clover sod, about May 10, and destroyed the first planting of corn, and were at the date of writing making way with the second planting, working underground and eating the plants from the roots upward to the surface of the ground.

The larvæ are whitish, striped on the back with brown, head and cervical shield yellowish. Their general form is more slender and longer than that of ordinary cut-worms, being nearer that of *Gortyna*.

(*Crambus zeellus* et al.)

While natural enemies of the larvæ of various species of *Crambus* have been recorded, those attacking the adult moths are, so far as published record goes, rather limited in point of numbers.

One of the probable enemies of our corn-destroying *Crambus* is a Neuropter, a *Bittacus* near *stigmaterus*. During August Mr. W. O. Pritz brought me an example which he had observed to attack a female moth, chasing her about, finally worrying her down and killing her. The remains of the moth when brought to me were too much mutilated to determine.

Mr. J. N. Latta, of Haw Patch, Ind., tells me that the moths of *Crambus laquealellus*, which I observed in abundance in his yard, were destroyed in great numbers by the Wood Pewee, *Contopus virens* L.

THE WHITE GRUB.

(*Lachnosterna spp.* ?)

The present season has been marked by the most serious depredations of these pests that has occurred for many years. Pastures, meadows, and corn-fields have suffered in some instances to the extent of 75 per cent. of the crop. Fields this season devoted to corn, but for thirty years previous under cultivation, continuously producing some one of the cereal grains, have been very seriously damaged, large areas of the corn withering and dying in the hill during August and September, from five to twenty grubs being found in and about a single hill. As early as May 13, at the Experiment Station, they were destroying young barley growing on a plot of ground which had produced a crop of this grain for the six preceding years. Adjoining this plot of barley was another which had been devoted to oats during the same period, but which was only slightly attacked. A precisely similar plot of buckwheat, which had produced the same crop for the same period, was found also invaded, and on July 24 the grubs were found in the act of cutting off the plants, now several inches in height.

A number of experiments were made with various substances with a view of determining the possibility of destroying the grubs without injury to the plant infested. Corn was the plant used in these experiments, being at the time the most convenient to obtain; the substances used, however, had they been ever so effective, could hardly be applied with practical advantage by the extensive farmer.

Experiment No. 1.—Placed a grub about the roots of a single plant on May 14; two days later, applied a sufficient amount of air-slaked lime to the surface of the ground to cover very lightly, watering thoroughly.

Result, May 22, plant killed but the grub uninjured.

Experiment No. 2.—Placed grub about roots of plant May 14; two days later applied table salt in solution at rate of 235 pounds per acre.

Result, five days later, plant and grub alike uninjured. A second application killed the plant but not the grub.

Experiment No. 3.—Placed grub about root of plant May 14; two days later applied fresh unleached ashes to surface of ground in sufficient quantity to cover lightly.

Result, five days after, plant and grub alike uninjured.

Experiment No. 4.—Single grub placed about roots of plant May 14; two days later applied 4 ounces gas-tar water.

Result, next day, plant killed; grub uninjured.

Experiment No. 5.—Single grub placed about roots of plant May 14; two days after earth about roots thoroughly saturated with tobacco water.

Result, five days after, plant and grub alike uninjured.

Experiment No. 6.—Single grub placed about roots of plant May 14; two days later applied 1 drachm Diamond soluble bone* in solution.

Result, six days later, plant and grub unaffected by application; grub eating off the roots.

Experiment No. 7.—Grub placed about roots of plant May 14; two days later ¼ ounce carbon bisulphide poured in hole made in earth near roots and immediately refilled with earth.

Result, second day after, plant and grub both dead.

Experiment No. 8.—Single grub placed about roots of plant May 14; two days after thoroughly saturated the soil with ammonial water of 1.025 specific gravity, 2.68 per cent. ammonia reduced 75 per cent.

Result, three days after, plant killed but the grub was alive and active.

Experiment No. 9.*—One grub placed about roots of plant May 22 and one drachm of phosphate salt applied in solution to the soil about roots. On 23d, corn was being destroyed by the grub and the next day the plant was wholly eaten off while his grubship appeared uninjured.

Experiment No. 10.†—Single grub placed about roots of plant and one drachm of fertilizing salt applied in solution to soil about roots.

Result, two days later, plant withering, grub all right but had not fed from plant which soon died.

Experiment No. 11.—Grub placed about roots of plant May 22; soil at once saturated with solution of powdered Pyrethrum and water; 1 ounce of powder to gallon of water.

Result, two days later, neither plant nor grub injured.

Experiment No. 12.—Grub placed about roots of plant May 22; next day the soil about the roots was drenched with decoction of Burdock leaves.

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* Analysis:

	Per cent.
Available phosphoric acid	13 to 15
Insoluble phosphoric acid	1 to 3
Total	15 to 17
Ammonia	½ to 1

† The phosphate salt and fertilizing salt used in experiments 9, 10, and 14, were sent to the Indiana experiment station by the manufacturer, E. S. Fitch, Bay City, Mich.,

Result, two days later, plant untouched; grub active, but seemingly unaffected by application.

Experiment No. 13.—October 6, earth in field in the vicinity of wheat plants being destroyed by white grub, thoroughly drenched with decoction of Burdock leaves.

Result of examination on October 14: The grub was found a short distance from the plants uninjured, it having evidently destroyed several after application of liquid.

Experiment No. 14.—October 3, earth about wheat plants, being destroyed in field by white grub, thickly covered with fertilizing salt and drenched with water.

Result of examination October 14 exactly as in the preceding, except that the grub was at a greater distance from plants.

Up to the present time, no Dipterous parasite has been recorded as preying upon white grubs, as the subterranean habits of the pest contributes to its protection in this respect. There is, however, pretty good evidence that there is at least one species of fly which exists to some extent in holding these grubs in check. On September 21, while

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who advertises both as not only being excellent fertilizers, but also very destructive to insect life, especially chinch-bugs and cut-worms.

The following analyses were kindly made for me by Prof. Henry A. Huston, chemist of Indiana experiment station:

I. *Phosphate salt.*

A. Qualitative analysis.

Bases present:	Acids present:
Calcium,	Hydrochloric,
Sodium,	Sulphuric,
Iron, trace,	Carbonic,
Aluminium, trace,	Silicic, trace,
Magnesium, trace,	Phosphoric, trace.
Organic matter, trace.	

Principal constituents: Common salt, gypsum, carbonate of lime.

B. Per cent. phosphoric acid present, .03.

II. *Fertilizing salt.*

A. Qualitative analysis.

Bases present:	Acids present:
Sodium,	Hydrochloric,
Calcium, trace,	Sulphuric, trace,
Organic matter, trace,	Silicic, trace.
Phosphoric, slight trace.	

Chief constituent: Common salt.

B. Quantitative analysis.

	Per cent.
Salt (NaCl)	97.70
Gypsum (CaSo)	.44
Insoluble matter	.47
Moisture	1.09
Soluble organic matter and loss	.30
Total	100.00

Samples drawn at experiment station from full sacks, special care being taken to insure fair samples. Neither of these samples contain an appreciable amount of phosphoric acid, potash, or nitrogen.

collecting material for experimentation, in a field seriously damaged by grubs, we found a hill of corn, which, though it contained none of the depredators, bore every evidence of having been destroyed by them, as other hills in a similar condition about it contained from 5 to 10 individuals. Instead, however, a larva of a species of *Erax*, near *bastardi*, was found. As the larvæ of *Erax* are known to be carnivorous, we can only conclude that the one found had made way with the grubs, but not until after the latter had destroyed the corn.

THE VARYING ANOMALA.

(*Anomala varians*, Fabr.).

The only record of this species, as a grain destroying insect occurs in the report of the Commissioner of Agriculture for 1884, p. 412, where Mr. Eugene F. Barns, of Marion, Marion County, Kans., reported the beetle as working serious damage to wheat in the field during the month of June, destroying 1,000 bushels for one farmer.

These beetles occur generally over the State of Indiana, and we have frequently met them hovering on heads of wheat in the field, but never remarked any serious injury. In this State the adult insects are preyed upon by one of the *Asilidæ*, *Laphria tergissa* Say, and we have several times caught these flies on wing with one of the beetles in their clutches, their beak puncturing the body of their victim.

THE WHEAT WIRE-WORM.

(*Agriotes mancus*, Say.)

A number of experiments were made with a view of learning the effect of the applications of salt, as against the larvæ of this species.

The method employed was to place a number of kernels of corn in earthen pots, and transport larvæ from the fields, where they were engaged in destroying wheat, placing them among the corn in these pots, the salt being applied in different quantities to the surface of the ground.

Experiment No. 1.—April 26, six kernels of corn, and two wire-worms nearly full grown, were placed together in a pot filled with earth, the latter being saturated with water from beneath. Common barrel salt was then applied to the surface of the soil, at the rate of 940 pounds to the acre. May 1, watered from above.

Result, the pot was examined May 7, and both worms found unaffected, they having in the meantime eaten nearly all of the corn, the uninjured kernels failing to germinate.

Experiment No. 2.—This was made at the same time as No. 1, all conditions being the same, except that salt was applied at the rate of 470 pounds per acre.

Result the same as in experiment No. 1.

Experiment No. 3.—May 7, placed three of the larvæ used in the preceding experiments and one fresh from the field, with corn in pot of earth, saturating the latter from below, and covering surface with salt in the proportion of 24,500 pounds per acre.

Result five days later; the worms were alive and as active as they ever were. Corn slightly eaten, but none showing any indication of growing, while kernels from same ear planted in unsalted soil were sprouted. The corn used in all experiments was from the same ear.

Drasterius elegans Fab.

The larva of this species has been mentioned in my previous reports as destroying other insects, and themselves injuring young corn. In the present instance they were found exceedingly abundant, on November 15, near New Castle, Ind., where they were evidently working seri, ous injury to a field of young wheat, sown in growing corn about September 5. This field had produced three consecutive crops of wheat-then the present crop of corn, among which the young wheat was growing. It was true the wheat was seriously infested by Hessian fly, and therefore the question may arise as to whether the worms were not destroying these; but the damage to the field was by far too great to have been done by the fly alone, and many of the plants had been eaten off below the ground.

With this new revelation regarding their food habits, it seems probable that a part of the wire-worm injuries to wheat sown among corn may be due to this species, instead of the preceding.

THE TWELVE-SPOTTED DIABROTICA.

(*Diabrotica* 12-*punctata.*)

The adults of this species have been observed in greater abundance than ever before. Gardens and fields have been literally overrun with them. The sexes were observed pairing as early as the 17th of April, thereby promising larvæ sufficiently early to attack young corn, even though planted at the usual time. The list of food plants has this season been observed to include the following, not previously reported: Wheat, cabbage, cauliflower, and beans; an adult was also observed feeding on volunteer oats December 14.

THE SWAMP SPHENOPHORUS.

(*Sphenophorus ochreus* Lec.)

Few insects afford a better illustration of the fact that a comparatively harmless species may, by force of circumstances, suddenly become extremely injurious. Known to the entomologist since 1858, and by no means a rare insect, its habits unstudied because of its secluded haunts and valueless food plant, the species appears to have been overtaken by this progressive decade in agriculture.

The swamp composing the field which formed the basis of the study of this insect was broken up some thirty years ago and two crops of corn raised on it without damage from insect attack, after which, by reason of being too wet, it was allowed to revert back to its original state. Fifteen years ago a second attempt was made to bring it into cultivation, and a single crop of corn raised from a portion of it, this time the insects being noticed, but doing no material injury. The land

was again allowed to go back to its primitive state, and remained thus until last season, when, after being drained, a portion was broken and the remainder brought into cultivation the spring of the present year, with the results here given.

Other fields of swamp land, in the same neighborhood, have suffered in the same manner as this one, but there is at present no information of serious damage until within the last three or four years.

The first published notice of the destructive habits of these insects is found in a brief notice which appeared in several agricultural papers during July, 1888, to the effect that Professor Forbes had found them to be very destructive to corn planted on recently drained swamp lands in Illinois, the adult feeding upon a species of rush (*Scirpus*) and a common reed (*Phragmites*), and when these were destroyed they transferred their attention to the young corn.

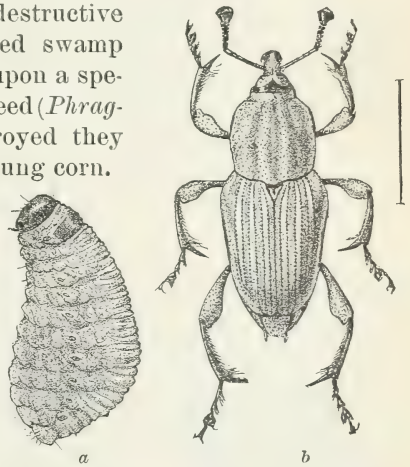

FIG. 1.—*Sphenophorus ochreus: a*, larva; *b*, adult—enlarged (after Riley.)

On May 23, adult beetles were sent me by Mr. Quincy Earl, a farmer residing near Dayton, Ind., a small village about 8 miles from La Fayette, with the statement that they were destroying his corn.

The beetles were at once confined with corn plants growing in flower pots, the males proceeding to bury their snouts into the tender stems, near the surface of the soil; but the females, to my utter astonishment, burrowed down into the earth, out of sight, and staid there.

Stormy weather prevented my visiting the locality until June 2. The infested field comprised about 75 acres of recently drained swamp land, plowed the present spring, except a small portion which had been devoted to corn the previous year, and the first and second planting destroyed by the beetles. On that portion of the field plowed this spring the young corn was not yet up, but on that portion which had been cultivated last year and planted earlier this year than the newer-plowed portion, the young plants had been totally destroyed, the lack of their natural food having evidently driven the insects to this part of the field, as other fields in the vicinity had not suffered the second year after the ground was first broken, although the first crop had been destroyed. At the time of my visit the beetles were feeding on a species of rush, *Scirpus atrovirens*, Muhl., puncturing the stems just below the surface of the ground and eating out the tender, folded leaves. The sexes were pairing, but I could get no eggs. A large number of adults of both sexes were taken home, as also were specimens of the *Scirpus*, including the roots, which are bulbous and exceedingly hard and compact. These plants were placed in flower-pots, and on each was placed a single pair

of adults. The next day the males were engaged either in pairing or feeding upon the *Scirpus*, but the females, when not paired with the males, had burrowed down into the earth, out of sight.

On a second visit to the infested field, June 11, but few females were to be found above ground. The young corn was coming up well, but being rapidly destroyed by the males and a few females, except where *Scirpus* was growing in sufficient abundance to provide an ample supply of food.

Absence from home, from the middle of June until the middle of July, not only interrupted my observations, but a press of other work prevented my visiting the field again until August 21, both plants and beetles in pots having in the mean time died.

As a result of this last visit I found two adults, one of which was feeding on a small dwarfed stalk of corn and the other on *Scirpus atrovirens*. An examination of the root of this reed revealed full-grown larvæ (Fig. 1, *a*) and fully developed adults still within the bulbs. Other bulbous roots of the same plant gave evidence that the adult had only recently quitted its birthplace. Hurrying home, my plants in the flower pots, long ago dead, dried up and, as I thought, worthless, were examined and in nearly every one was found a fully developed adult, none of which had escaped from the bulbous roots wherein they had developed. (Fig. 2.)

FIG. 2.—Work of *Sphenophorus ochreus* in roots of *Scirpus*—natural size (after Riley).

Still another visit to this field on August 30 confirmed all previous observations, and a single pupa was also found in a bulb of the *Scirpus*.

From what is known of the habits of other species of this genus, coupled with the fact that fields of corn are not attacked by the beetles after the first year following the breaking of the ground, it seems highly improbable that there should be more than one annual brood. This being the case, its life history will likely be as follows: The insect hibernates in the adult stage, coming forth from its hiding places in spring, the females depositing their eggs during May and June in the roots of *Scirpus*. The larvæ hatching from these develop to adults and emerge in about three months.

From the vast differences existing between the plant in which the species breeds and that of the corn plant, the great improbability of the insect ever breeding in corn will at once be seen. The whole problem of prevention seems to settle in the destruction of these reeds, root and stem, the season prior to devoting the ground to corn. The eggs are as a rule deposited in bulbs formed the preceding year, and

we have found healthy adults in bulbs after the latter had been thrown out by the plow and lain in the sun for over a month. We have also found them developing in bulbs in ground plowed in May and again in July, indicating that little or nothing can be accomplished by summer fallow.

The most practical and probably the most effective method of destroying the food plant of the pest is to sow rye or some other crop on the land the first season after breaking.

THE CHINCH BUG.

(*Blissus leucopterus* Say.)

The history and distribution of the Chinch Bug in Indiana offers some problems not only very perplexing but exceedingly difficult to solve. In fact, we shall here make no attempt toward a solution, but rather to separate a few of the many complex elements which are thought to influence the distribution and numbers of the pest, and to some extent at least indicate how far they may be considered or perhaps eliminated entirely from any independent relation to the subject, thereby affording aid to the future investigator.

It is well known that although Thomas Say, at the time he described the species, was residing at New Harmony, Indiana, nevertheless his description was drawn from a single specimen taken by himself on the Eastern Shore of Virginia, and so far as we know he may have died ignorant of its occurrence in his own or any of the adjoining States.

Recently, Professor Forbes has collected some data showing that the species was destructively abundant in Edwards County, Illinois, as early as 1828, and was also observed in Richland County in 1823.

Strictly in accordance with the above, while that portion of Illinois lying adjacent to Indiana, separated only by the Wabash River, has suffered again and again through the ravages of the Chinch Bug, crops on the Indiana side have not often suffered from any extensive or widespread ravages of the pest. Not only this, but at the present time the worst infested portion of Indiana is composed of those counties whose western border is the Wabash River, which separates them from Illinois, and from whence the insect occurs in continually diminishing numbers northward and eastward until we reach the northern counties of La Porte, St. Joseph, Elkhart, La Grange and Steuben, where its depredations are almost entirely unknown.* Indeed, during the years when they are the most numerous elsewhere, I have found them in these counties only with difficulty, and few of the farmers know what the insect is like. In almost exactly the same latitude in De Kalb County, Illinois, within 60 miles of Lake Michigan, they have been a serious pest since 1855.

* The only exception known to me was in Elkhart County, where they were reported to Mr. J. R. Dodge, Statistician of the Department of Agriculture in 1887. (See Bull. 17, U. S. Dept. Agri., Div. Ent., p 9.) Mr. Dodge has very kindly looked up this matter, and writes me that these bugs were only reported from one locality in very limited numbers and did no appreciable damage.—F. M. W.

A line drawn from the northwestern corner of Indiana diagonally across the State to the Ohio line, at the southeast corner of Jay County, will divide from the remainder of the State nearly all of twenty-four counties over which the Chinch Bug is either unknown or occurs in too limited numbers to cause serious damage. These are the counties enumerated in Tables A and B. As the numbers of counties from which I have information of serious and wide-spread damage does not amount to twenty-four, I have added others, in which we have observed considerable numbers of Chinch Bugs, and filled out the number with counties situated in the infested district. These are enumerated in Tables C and D.

TABLE A.—*Acreage of various grains produced in* 1887 *throughout the area over which Chinch Bugs do not occur in destructive numbers.*

Counties.	Wheat.	Oats.	Rye.	Barley.	Total small grain.	Corn.	Excess of small grain over corn.
Adams	26,936	9,142	255	35	36,368	30,257	+ 6,111
Allen	48,362	25,687	2,065	101	76,215	42,004	+34,211
Blackford	12,543	2,544	196	41	15,324	16,000	— 676
De Kalb	30,097	13,390	211	157	43,855	22,135	+21,720
Elkhart	44,896	15,207	705	90	60,898	35,145	+25,753
Fulton	29,903	5,684	390	35	36,012	25,827	+10,185
Grant	42,077	5,455	347	147	48,026	49,225	— 1,199
Huntington	34,888	10,693	800	195	46,576	38,145	+ 8,431
Jay	29,588	8,766	275	145	38,774	39,656	— 882
Kosciusko	42,268	13,274	240	162	55,944	40,065	+15,879
LaGrange	36,903	9,818	873	37	47,631	28,292	+19,339
Lake	2,808	26,690	1,284	275	31,057	30,637	+ 420
La Porte	43,904	15,054	802	335	60,095	39,690	+20,405
Marshall	35,062	10,145	1,244	186	47,637	33,238	+14,399
Miami	44,212	7,919	139	168	52,438	42,301	+10,137
Noble	38,797	12,345	120	44	51,306	29,452	+21,854
Porter	15,312	16,365	1,026	236	32,939	21,042	+11,897
Pulaski	19,267	7,828	1,570	394	29,059	23,686	+ 5,373
Starke	3,591	2,916	1,657	298	8,462	7,911	+ 551
Steuben	27,414	9,253	219	310	37,196	22,200	+14,996
St. Joseph	41,525	11,482	440	30	53,477	30,698	+22,779
Wabash	41,109	8,391	115	149	49,764	45,638	+ 4,126
Wells	32,301	6,196	572	54	39,123	39,322	— 199
Whitley	25,633	9,727	95	45	35,500	24,753	+10,747

TABLE B.—*Acreage of various grains produced in* 1888 *throughout the area over which Chinch Bugs do not occur in destructive numbers.*

Adams	23,130	16,818	249	51	40,248	31,417	+8,831
Allen	50,469	27,228	1,895	172	78,764	43,775	+34,989
Blackford	11,057	3,280	253	140	14,730	16,633	−1,903
De Kalb	28,145	14,249	138	169	42,701	25,474	+17,227
Elkhart	43,818	14,783	1,013	78	59,692	36,663	+23,029
Fulton	33,976	6,306	267	12	40,561	29,795	+10,766
Grant	38,808	5,593	316	201	44,918	48,581	−3,663
Huntington	32,639	10,990	218	186	44,033	40,218	+3,815
Jay	25,433	9,666	311	160	35,570	40,750	−5,180
Kosciusko	39,878	14,201	334	135	54,548	41,025	+13,523
Lagrange	33,540	10,285	750	55	44,630	30,252	+14,378
Lake	3,874	21,026	1,330	221	26,461	29,510	−3,049
La Porte	40,642	18,033	772	787	60,234	41,345	+18,889
Marshall	33,187	11,095	1,449	271	46,012	37,134	+8,878
Miami	44,250	8,160	126	188	52,724	42,743	+9,981
Noble	37,983	14,336	217	44	52,580	29,915	+22,665
Porter	16,648	17,428	1,593	213	35,882	27,863	+8,019
Pulaski	17,007	3,407	1,633	282	29,339	26,232	+3,097
Starke	3,965	3,476	1,696	237	9,374	8,633	+741
Steuben	25,944	10,288	310	317	36,859	21,373	+15,486
St. Joseph	37,602	12,170	642	714	51,128	29,343	+21,785
Wabash	40,202	9,892	183	73	50,350	44,080	+6,270
Wells	28,437	8,352	611	147	37,547	38,009	−462
Whitley	21,789	10,647	65	39	32,540	23,503	+9,037

TABLE C.—*Acreage of various grains produced in* 1887 *throughout the area over which Chinch Bugs occur sometimes in destructive numbers.*

Counties.	Wheat.	Oats.	Rye.	Barley.	Other small grain.	Corn.	Excess of small grain over corn.
Benton	1,592	35,529	390	125	38,036	71,714	—33,678
Clay*	22,610	9,963	160	211	32,944	26,447	+6,497
Crawford*	7,513	9,389	25	.....	16,927	15,491	+1,436
Daviess	40,186	10,575	340	42	51,143	39,472	+11,671
Dubois*	24,527	10,950	20	87	35,584	22,042	+13,542
Gibson*	72,513	5,740	386	31	78,670	45,108	+33,562
Green	24,943	11,930	239	178	37,290	34,141	+3,149
Jackson	27,584	14,733	297	45	42,659	42,633	+26
Knox*	48,483	6,426	207	68	55,184	47,331	+7,853
Lawrence	11,423	14,395	136	51	26,005	25,228	+777
Martin	15,740	7,766	136	191	23,833	21,493	+2,440
Monroe	9,505	9,399	35	40	18,979	16,462	+2,517
Orange	12,322	17,708	84	96	30,210	26,836	+3,374
Owen	14,343	9,705	91	20	24,159	16,910	+7,249
Parke	33,828	9,426	297	66	43,617	39,751	+3,866
Pike	35,698	9,080	83	107	44,968	30,095	+14,873
Posey*	60,902	6,600	120	47	67,669	38,979	+28,690
Putnam	33,544	7,613	117	96	41,370	37,006	+4,364
Sullivan*	33,624	10,059	826	55	44,564	44,109	+455
Tippecanoe	49,339	14,657	544	120	64,660	79,497	—14,837
Vermillion	30,274	6,724	352	98	37,448	35,549	+1,899
Vigo	35,738	13,096	694	217	49,745	50,082	—337
Warrick*	30,088	9,609	62	40	39,799	33,171	+6,628
Washington*	17,245	19,028	77	68	36,418	30,206	+6,212

TABLE D.—*Acreage of various grains produced in* 1888 *throughout the area over which Chinch Bugs occur sometimes in destructive numbers.*

Benton	2,470	36,801	372	81	39,724	84,751	—45,027
Clay*	22,136	10,720	178	150	32,184	28,100	+5,084
Crawford*	9,527	7,216	13	10	16,766	14,502	+2,264
Daviess	39,049	11,194	280	75	50,598	39,259	+11,339
Dubois*	26,414	10,168	48	128	36,758	22,799	+13,959
Gibson*	68,640	5,606	466	116	74,828	48,280	+26,548
Green	30,962	12,627	253	84	43,926	35,745	+8,181
Jackson	27,425	14,135	254	34	41,848	43,007	—1,159
Knox*	47,798	6,869	222	163	55,058	54,001	+1,051
Lawrence	10,559	14,392	208	79	25,238	31,666	—6,328
Martin	14,450	8,797	124	126	23,497	20,928	+2,569
Monroe	10,147	8,500	64	22	18,733	16,241	+2,492
Orange	13,446	15,246	94	78	28,864	25,406	+3,458
Owen	13,329	10,402	82	43	23,856	17,422	+6,434
Parke	33,523	9,718	256	57	43,554	44,771	—1,217
Pike	30,934	10,154	54	106	41,248	32,062	+9,186
Posey*	59,006	7,465	108	39	66,618	46,711	+19,907
Putnam	32,139	8,194	131	74	40,538	39,358	+1,180
Sullivan*	29,377	11,279	798	68	41,522	45,808	—4,286
Tippecanoe	53,000	15,313	570	129	69,012	82,611	—13,599
Vermillion	29,985	7,710	439	76	38,210	35,444	+2,766
Vigo	36,157	14,327	557	203	51,244	52,084	—840
Warrick*	30,562	10,191	144	57	40,954	34,589	+6,365
Washington*	18,465	19,922	39	46	38,472	34,911	+3,561

* Counties marked with asterisk (*) are those in which Chinch Bugs have been reported in destructive numbers.

Much has been said of late of the influence which the cultivation of wheat and other grains has on the numbers and distribution of the Chinch Bug. Tables A, B, C, and D, here given show the acreage of each of the cereal grains in forty-eight counties for the years 1887 and 1888. It will be observed that among the uninfested counties there are but four which had a greater area of small grain than of corn in 1887 and in 1888. In 1887, in eleven of these same counties, the area of wheat exceeded that of corn, in six of which counties the Chinch Bug

is unheard of. Practically the same state of affairs existed in 1888, both as to crop and bugs. In the twelve counties more or less infested with bugs in 1887, four had a larger area of corn than of small grain, and all but seven showed a greater area of corn than wheat. In 1888 only three had a greater area devoted to wheat than corn, and six had a greater area of corn than of small grains. It will be observed that Sullivan County, which probably suffers from Chinch Bug injury as bad as any portion of the State, is one of these. It appears therefore that the nature of the crop has of itself nothing to do with the distribution of the Chinch Bug in Indiana.

TABLE E.—*Total amount, in inches and tenths, of precipitation and mean temperature, in degrees and tenths, at Princeton, Gibson County, Ind., latitude 38° 23′ N., during the months of April, May, and June, for the years* 1885, 1886, 1887, 1888, *and* 1889.

Year.	April.		May.		June.	
	Precipitation.	Temperature.	Precipitation.	Temperature.	Precipitation.	Temperature.
1885	3.70	53.5	2.30	61.5	5.90	71.9
1886	3.50	55.3	2.10	66.1	4.90	71.3
1887	2.30	53.2	6.10	68.0	.10	74.3
1888	1.50	55.3	1.95	63.5	2.50	76.7
1889	.80	55.2	4.40	64.4	3.60	70.7

TABLE F.—*Total amount, in inches and tenths, of precipitation and mean temperature, in degrees and tenths, at Angola, Steuben County, Ind., latitude 41° 37′ N., during the months of April, May, and June, for the years* 1885, 1886, 1887, 1888, *and* 1889.

1885	4.35	45.6	6.95	56.9	4.32	66.9
1886	2.77	52.5	3.49	63.5	4.16	67.2
1887	1.12	45.2	1.95	70.8	5.24	71.2
1888	1.64	46.5	3.75	61.9	5.16	70.6
1889	1.19	49.2	5.25	61.4	3.50	68.5

TABLE G.—*Total amount, in inches and tenths, of precipitation and mean temperature, in degrees and tenths, at Sandwich, De Kalb County, Ill., latitude 41° 31′ N., during the months of April, May, and June of the years* 1885, 1886, 1887, 1888, and 1889.

1885	2.46	46.71	1.30	58.65	2.94	68.95
1886	1.35	56.40	3.06	64.70	1.28	68.82
1887	.57	53.12	1.87	68.55	1.77	75.07
1888	1.70	49.84	5.14	58.72	2.76	72.48
1889	3.15	52.03	3.08	61.71	5.40	68.62

Neither can this unequal distribution be attributed to the interspersion of timber lands among the cultivated fields, as the northern and southern portions are about equally wooded, and, besides, the treeless prairies of the State are not particularly subject to invasions of Chinch-bugs. Low temperature can hardly be held responsible for the phenomenon, as the ravages in more northern localities like Nebraska, northern Iowa, and in Minnesota will attest. Coming northward from the Ohio River, during the season of drought which has occurred each year since 1886, one can not help but admit that the effects of dry

weather are greatest in the southern portion of the State. But the difference between this weather condition is certainly not so marked between Tippecanoe and Benton Counties on the one hand, and La Porte and Lagrange Counties on the other, as to result in a difference in the number of bugs amounting to that between a great abundance and almost none at all. In Tables E, F, and G are given the mean temperature and rain-fall for the months during which these elements most affect the Chinch Bug, and extending over a period of five years.* This is as far back as the Indiana records extend. The records from Princeton, Ind., indicate the meterological conditions during this period in the bug infested area, and those from Angola are a like record of the weather conditions in the region exempt from Chinch Bug attack, while Table G gives the meterological conditions in De Kalb County, northern Illinois, where Chinch Bugs have been abundant since 1855, formerly doing serious damage to spring wheat, and have, since about 1862 (wheat of any sort being no longer grown to any extent), been transferring their attention to the corn crop, but being at present less abundant than in southeastern Indiana or southern Illinois.

From a study of the tables given it will be seen that while the northern Illinois locality had a less rain-fall during the spring and early summer than the northern portion of Indiana, it also had a less amount than had southern Indiana; yet, while Chinch Bugs are more numerous in the Illinois section than in northern Indiana, they are not so abundant as in southern Indiana.

Geologically, the northern portion of Indiana differs from the southeastern portion, the former being Devonian and the latter carboniferous or subcarboniferous. This, however, could have little effect on the Chinch Bug, except, possibly, so far as it influenced the natural flora, especially the grasses. Prof. James Troop, who has made the grasses of Indiana a study, informs me that the following are all, or nearly all, the species found in the southern portion of the State which do not occur in the northern portion: *Uniola latifolia*, *Arundinaria tecta*, *Paspalum fluitans*, *P. lœve*, *Panicum prolificum*, *P. anceps*, *P. vicidum*, *Andropogon divisitiflorus*.

From the foregoing it will be seen that to no one of these elements alone, as existing between southwestern Indiana and Illinois on the one hand, and northeastern Indiana, southern Michigan, and northern Ohio on the other, can this immunity from Chinch Bugs in these last localities be traced. Whether the combination of two of these elements, such as dry weather and wheat-growing, is to be held wholly responsible, or whether there is still another potent element, as yet unknown to us, which, either in itself or combined with some other, is the prime cause of the present state of affairs, only future studies can demonstrate.

* Kindly supplied me by N. E. Ballou, M. D., Ph. D., Sandwich, Ill., for thirty years volunteer signal observer at that place.—F. M. W.

That dry weather during spring and early summer is almost invariably associated with an increase, and wet weather during the same period with a decrease of Chinch Bugs is usually true, but why this is so has never been definitely explained.

The fungoid disease known as *Entomophthora* has, since it was studied by Dr. Shimer, been known to be much more fatal in wet than in dry weather. How far this would prove true, and to what extent the farmer could rely upon this fungus to keep the Chinch Bug in check, gave the incentive for carrying out the following experiments.

Early in July, 1888, a large number of Chinch Bugs, principally pupæ nearing the last molt, were placed in a close glass vessel and kept in a very damp atmosphere and under high temperature. Although kept for two weeks under these conditions we failed to produce the *Entomophthora* among them. This was accepted as evidence that the fungus did not exist in any stage of development here at La Fayette, Ind., although it was reported from an adjoining State.

On July 20, of the present year, we received some dead chinch bugs from Prof. F. H. Snow, of Lawrence, Kans., which were said to be affected by *Entomophthora*. These diseased bugs were placed under glass with living ones from the fields, the latter being provided with food and kept thus confined for fifty-three hours, when the major portion of them were placed on several hills of corn, seriously infested by bugs, the remainder with the dried remains received from Professor Snow being scattered about over a small area of young wheat sown for experiment, and also swarming with young Chinch Bugs. The hills of corn on which the bugs had been placed were isolated from others, equally badly infested, by narrow frames of boards placed on the ground, and the upper edges covered with tar. This last precaution was taken in order to prevent communication with other hills, intended as checks on those used directly in the experiment. The area of young wheat over which infested bugs had been placed was not inclosed, but its limits carefully marked. Five days after, July 27, a single bug was found on one of the isolated hills of corn which had very evidently died from the effects of *Entomophthora*, and by the 30th enough others were found to show that the fungus had fully established itself, and the barriers about the isolated hills were removed. On August 2, dead bugs covered with *Entomophthora* were found in considerable numbers about hills of corn, 25 feet from where the original colonies had been placed, and also throughout and even 55 feet beyond the area of young wheat over which dead and affected bugs had been distributed. Daily observations were now made, but the progress of the disease seemed to come to a stand-still. From the 5th of August up to the 9th it was almost impossible to get sufficient material, outside, to enable me to carry on laboratory experiments. August 13, the spread of *Entomophthora* appeared to have taken on new life, and diseased bugs were becoming much more numerous. August 15, found diseased bugs 172 feet from any place where they had been previously observed. August 20, diseased bugs were very abundant over all of

the area where disease had been distributed, and two days later examples were found a quarter of a mile from the starting point of the disease. Immediately after this, however, another halt, both in the intensity of attack and rapidity with which it spread, due either to the dry weather, or to the fact that the bugs had now all reached the adult stage, and had become diffused over the country, no longer congregating together. From either one or the other, or both of these causes, I lost track of the *Entomophthora* and was not able to again find it in the fields. It seems proper to state here that Chinch Bugs were not at any time excessively abundant. The greatest numbers were in the exact localities where the disease was first distributed, the congregating at these places being brought about by the close proximity to a large number of small experimental plats of wheat, and when this was harvested the bugs collected *en masse* on the corn and young wheat. In connection with these facts, it is also interesting to note that from July 15 to August 31 there were ten days on which rain fell. The dates of these rains and the amount of precipitation is given below:

Date.	Precipitation.	Date.	Precipitation.
	Inches.		*Inches.*
July 17	.02	July 29	.78
19	1.25	30	.50
22	.20	Aug. 9	3.36
23	.04	13	.15
26	.13	14	.02

With a view of learning whether or not there was any difference as regards susceptibility to the attack of *Entomophthora*, between bugs in different stages of development, a series of experiments was begun, as follows:

Young plants of *Setaria glauca* were transplanted to a box, and upon each plant was placed a dead bug covered with the fungus, and also healthy larvæ; larvæ just on the point of pupation; pupæ just prior to reaching the adult stage; and fully developed adults, each stage being placed on separate plants and each covered with a small inverted glass vial numbered by lettering. As checks, another series was prepared like the first in every particular. The soil in the box was kept well moistened, and the plants remained fresh. This experiment was made on August 2, about the time when the attack outside began to diminish in intensity. The following are the results of examinations on the dates indicated, the original experiments being numbered by capitals, and the checks by small letters, thus—A–a, adult; B–b, young larvæ; C–c, older larvæ; D–d, pupæ.

Date.	A.	a.	B.	b.	C.	c.	D.	d.
Aug. 5	Healthy	Healthy	Healthy	Healthy	1 dead	Healthy	1 dead	1 dead.
Aug. 6	1 dead	1 dead	Healthy	Healthy	1 dead	Healthy	3 dead	1 dead.
Aug. 7	All dead	3 dead	3 dead	1 dead	3 dead	1 dead	.....	5 dead.
Aug. 16	All dead	All dead	All dead	All dead	All dead	All dead	All dead	All dead.

On the same day this experiment was begun, a second was also commenced, like the first in every particular except that the healthy bugs used, in experimentation, were exposed to fungus infested individuals for only five hours, and then placed under their respective glasses. As a result on August 15, thirteen days after, none had died, thus strongly indicating that the *Entomophthora* did not exist generally in the fields, and that it could not be communicated during a period of five hours, exposure.

On August 7 a large number of healthy bugs were placed under glass, with a number which had recently died from *Entomophthora*, the moisture in the vessel being absorbed by calcium chloride. A check experiment was also commenced, where the material and the conditions were the same, except the humidity of the atmosphere, care being taken to have the latter as nearly saturated with moisture as possible. August 10, the original experiment was divided and a portion of the healthy bugs removed and placed in a damp environment, the remainder being kept under the original dry conditions. The results on August 22 were as follows. In the original experiment, where the healthy bugs had been continually in dry quarters, not a single bug had died from *Entomophthora*. Not only this, but none of those which had been removed after three days and placed in dry quarters had died, showing that the disease was not contracted and did not develop in healthy bugs, though kept exposed in a dry atmosphere for fifteen days, nor could it be originated by placing, in a damp atmosphere, for twelve days, bugs which had been exposed to contagion for three days in dry quarters. The results with the check experiment were quite different. Within five days after being confined with the *Entomophthora*, the healthy bugs began to die from effects of the disease, and in three days more every one had died from the same cause, their bodies being covered with spores.

Still another experiment was tried which consisted in confining a large number of healthy bugs with others diseased in a damp environment, and when the fungus had destroyed a portion the remainder were divided and a part removed to dry quarters. The result was that while those left in damp confinement continued to die, none of those inclosed in dry environment were destroyed. As the fungus had by this time become distributed over the experiment farm so that I could not tell with certainty whether material from the fields was in a perfectly healthy condition or not, no farther experiments were made in this direction.

From the foregoing it will be observed that the essential element in all of these experiments was an abundance of moisture, without which the *Entomophthora* could neither become established nor flourish after it had gained a footing. Again the extent to which the disease will prove contagious will depend upon the number of bugs. Without great numbers massed together comparatively few would contract the disease. To sum up the matter there is little hope for relief to the farmer from the influence of *Entomophthora*, except when Chinch Bugs

are abundant and massed together in great numbers, and during a period of wet weather. I have succeeded in getting the fungus established at two widely located points in Indiana, and do not consider it at all difficult to introduce in localities where Chinch Bugs are abundant, provided the weather is favorable. But if it is ever utilized by the farmer, which seems to me to be at present a matter of considerable doubt, it will only be after the pest has become very abundant, during the time between the first larval and adult stages and in a wet time. After the *Entomophthora* has been introduced into a certain field it will become diffused only in proportion as the bugs travel about and healthy bugs come in contact with spores from those which have died from the disease. This will not be very great until the pupal stage is reached.

The larvæ of Chinch Bugs seem to in some way understand that while moulting they will be well nigh helpless, and hence hide themselves away in vast numbers in secluded places. Under such conditions the spores thrown from diseased bugs would reach a larger number of their fellows. I have found adults but recently moulted affected by the *Entomophthora*. After the bugs acquire wings and scatter themselves over the country, the liability to contagion will be again reduced, unless in case of very severe invasions, where from force of numbers congregating on or about food plants becomes a necessity. Hence, the introduction of the fungus among larvæ will at first proceed but slowly, and only in extreme cases and under favorable conditions can it be expected to proceed much more rapidly among adult bugs. In short, the only way that this fungoid disease seems capable of being employed in agriculture is by the establishment of some central propagating station to which farmers can apply and receive an abundant supply of infested bugs on short notice. By this means they could take advantage of a rainy period of a week or ten days, and, if they can contrive by sowing plats of millet and Hungarian to mass the bugs in certain localities about their fields, they might accomplish something towards warding off an invasion. But the possibility of overcoming an invasion after it is fully under way, as is almost sure to be the case during a dry season, it must be confessed is not very encouraging. My failure after repeated experiments to produce this *Entomophthora* in the vicinity of Lafayette without the importation of germs is decidedly against the theory that might be advanced that the northeastern portion of the State was kept free of destructive invasions by reason of this disease brought about by wet weather. There is as yet no reason to believe that the disease has ever existed in that section of the State.

Before leaving the subject it will be proper to state that in my experiments a larva of *Chrysopa* was introduced by accident and passed through the larval stage, feeding continually on bugs dying from the effects of the fungus.

After harvest the Chinch Bugs, as usual, transferred their attention to various grasses which were growing up among the stubble, more especially *Setaria* and *Panicum*, but as these succumbed to their contin-

ued attacks they transferred their attention to Timothy, and appeared to subsist equally well upon it.

At the date of wheat-harvesting, fields were swarming with a species of lady beetle, *Coccinella 9-notata*, they having become excessively abundant by reason of the great numbers of the Grain Aphis, and as these disappeared the Coccinella was obliged to scatter themselves about and seek other food. As large numbers were found on stalks of growing corn infested by chinch-bugs, it seemed proper to determine the object of attraction to such places. The problem was in part solved by the fact that wherever great numbers of Chinch Bugs had punctured the corn plants the sap would exude from these punctured spots, and there the beetles would be found, singly or in groups of two or three, engaged in feeding upon the sap. Beetles placed under glass with a great number of Chinch Bugs refused to prey upon the latter, even when brought nearly to the point of starvation.

While searching under the sheaths of corn on several occasions larvæ and pupæ of a Syrphus fly were found, in many cases, right among the masses of young bugs. From some of these pupæ thus obtained we reared adults of *Pipiza pulchella*. Whether this species will ultimately prove to be an enemy of the Chinch Bug, it is too much to say, but the larvæ found by me could only have fed upon bugs or exuding sap, as they were near the roots of the corn where no pollen had collected.

THE GRAIN APHIS.

(*Siphonophora avenæ* Fab.)

Probably no insect has appeared in the State of Indiana for many years which caused such a general commotion among wheat-growers, and which worked so little damage, considering, its numbers, as this.

Occurring every year in greater or less numbers, and having been frequently sent us by farmers, we were not at all surprised to receive specimens from Gallatin County, Ill., on May 27, and also a few days later from our aged friend Dr. Richard Owen, of New Harmony, Posey County, Ind. Probably about May 20 can be set down as the date of appearance, in numbers to attract attention in the extreme southern part of the State, the invasion terminating in the extreme northern portion about the 1st of July.

That the outbreak, which was probably the most severe since 1861 and 1862, should reach the magnitude that it did, both in point of numbers and area infested, was a surprise to me, as the preceding November had been spent by myself in traveling about, visiting the wheat fields of various portions of the State, these insects then being observed in no greater numbers than was usual at that season of the year. The winter following was an extremely mild one, which, taken with the statement of Dr. Cyrus Thomas,* that the insect passes the winter on grain plants in the fields, might lead to a misunderstanding as to the actual effect of mild winters.

* Eighth Rep. St. Ent. Ill., 1879, p. 53.

The winters of 1861 and 1862, the years of the serious outbreaks in New York and New England, though not particularly severe in the sections above mentioned, were by no means noted for mildness. It seems doubtful, therefore, if the causes leading to the invasion of the present year would carry us farther back than the spring months, a statement strongly substantiated by our own observation.

Starting, then, with the month of March we search for some meteorological element which might affect the increase of the Grain Aphis, and which appears both in the present season and also in 1861 and 1862.

TABLE H.—*General weather conditions in various localities during years of great abundance of Grain Aphis.*

Locality.	Year.	March.	April.	May.	June.
New York and New England	1861	Cool	Cool	Cool	Cool.
		Average.	Wet	Wet	Dry.
	1862	Cool	Cool	Cool	Cool.
		Wet	Wet	Dry	Dry.
Indiana	1889	Warm	Warm	Cool	Cool.
		Dry	Dry	Dry	Wet.
Western New York	1889				Cool. Wet.

The weather conditions as relating to New York and New England for 1861 and 1862, as given in Table H are based upon reports contained in the Country Gentleman for these years. Those for Indiana are based on the reports of the State Weather Service, and the data for western New York, for 1889, was given me by Prof. James Troop, Horticulturalist of the Indiana Experiment Station, who visited Livingston County in July.

From Table I, taken from Indiana Weather Service reports, it will be observed that during March and April the temperature was considerably above the normal, with the precipitation during this time below the average. On the other hand, the temperature of the months of May and June was much below the normal, with, as indicated by Table I, precipitation above the average. By referring to Table K, however, it will be observed that about half of the precipitation of May fell on the 29th and 30th of the month, thereby changing the apparent state of affairs, and practically throwing May into the dry period.

We have stated that the outbreak of the grain Aphis became conspicuous in southern Indiana and Illinois in May. It is also true that they reached their maximum numbers during the very last of this month and early June. In other words, they appeared during cool, dry weather, and disappeared in cool, wet weather. Thus far the old theory of entomologists, that wet weather is detrimental to their increase appeared true.

But it is also true, that while in southern localities they were disappearing during a wet period, in central and northern Indiana and western New York they were rapidly gaining in numbers, under precisely similar conditions.

Turning now to Table H, we search for an element common to the invasions of 1861 and 1862 and 1889, bearing in mind that in southern Indiana the pest arose to the maximum during May and early June, and in New York during June and early July.

TABLE I.—*Comparative temperature and precipitation throughout the State of Indiana for March, April, May, and June,* 1889.

TEMPERATURE (DEGREES—FAHRENHEIT).

Counties.	Stations.	Number of years.	March.		April.		May.		June.	
			Normal.	Departure from the normal.	Normal.	Departure from the normal.	Normal.	Departure from the normal.	Normal.	Departure from the normal.
Southern		5	41.1	+2.8	54.8	—0.1	64.4	—1.9	72.2	—2.5
Dubois	Huntingburgh	6	41.4	+4.6	54.6	+2.1	64.0	-1.4	72.8	—1.0
Gibson	Princeton	5	41.8	+4.7	54.1	+1.1	64.7	—0.3	74.0	—3.3
Crawford	Marengo	6	42.3	+3.1	57.7	+1.1	65.3	—0.9	72.2	—0.3
Washington	Salem	6	41.3	+0.2	53.2	—0.1	64.2	—0.1	.....	.....
Switzerland	Vevay	21	42.8	+3.9	54.8	+1.3	65.4	—0.8	74.4	—3.5
Jennings	Butlerville	4	42.4	+2.9	55.5	—2.0	65.7	—4.0	73.7	—3.2
Greene	Worthington	6	39.6	+1.5	53.9	+0.9	63.9	—3.2	70.2	—2.4
Bartholomew	Columbus	6	38.4	+2.7	52.2	+0.2	63.4	—2.4	72.2	—3.7
Ripley	Sunman	6	39.4	+3.0	53.4	+0.4	65.3	—3.0	72.5	—4.3
Warrick	Dagonia Springs	6	43.4	+2.1	55.8	—0.7	64.6	—2.5	72.0	—2.3
Clark	Blue Lick	12	42.9	+3.1	55.3	+1.14	64.5	—1.4	74.3	—2.3
Central		5	36.7	+4.9	51.0	+0.3	61.9	—1.0	70.4	—2.6
Johnson	Franklin	6	37.9	+5.1	52.0	+1.4	63.0	—1.2	70.8	—2.5
Fayette	Connersville	7	37.8	+5.5	49.8	+3.0	62.6	—1.1	71.3	—3.6
Marion	Indianapolis	18	39.8	+2.8	52.5	+0.1	64.1	—3.9	72.5	—5.3
Rush	Mauzy	8	35.0	+6.1	49.2	+0.4	60.7	—1.2	68.7	—0.3
Henry	Spiceland	35	37.0	+6.0	50.0	+2.6	61.6	+0.7	70.5	—2.5
Wayne	Richmond	6	35.9	+2.0	50.5	—3.1	62.0	—4.1	69.5	—2.5
Randolph	Farmland	6	36.4	+6.0	48.7	+2.8	61.3	—0.3	69.7	—2.3
Delaware	Muncie	4	38.1	+5.2	52.3	—1.8	62.2	—1.1	70.0	—1.5
Northern		5	34.5	+3.8	49.9	—0.1	61.0	—2.4	70.0	—3.8
Tippecanoe	Lafayette	10	36.1	+1.7	54.7	—3.9	61.4	—2.1	70.0	—3.8
Carroll	Delphi	4	36.0	+1.7	51.6	—1.4	62.3	—2.7	.....	.....
Whitley	Columbia City	4	34.7	+1.9	48.9	—0.9	60.0	—2.7	69.5	—5.6
Steuben	Angola	5	31.7	+6.3	47.8	+1.4	63.1	—1.7	68.9	—0.4
State		7	37.4	+3.9	51.9	0.00	62.1	—1.4	70.9	—3.0

PRECIPITATION (INCHES).

Southern		5	2.67	—1.49	3.26	—2.45	3.94	+1.56	4.07	+0.65
Dubois	Huntingburgh	6	3.28	—2.48	2.98	—3.30	3.92	+2.63	3.86	—0.24
Gibson	Princeton	5	2.45	—0.45	2.43	—1.63	3.09	+1.31	3.55	+0.05
Crawford	Marengo	6	3.25	—2.15	5.28	—4.68	6.00	+3.85	5.27	+1.25
Washington	Salem	6	2.62	—1.56	3.68	—2.58	3.24	+2.05	.....	.....
Switzerland	Vevay	21	4.03	—3.20	3.40	—2.48	3.53	+2.64	5.07	—0.61
Jennings	Butlerville	4	3.35	—2.21	2.93	—1.72	5.56	+0.87	5.56	—1.85
Greene	Worthington	7	2.59	—0.58	3.04	—1.50	4.19	—1.29	4.51	+2.81
Bartholomew	Columbus	6	2.52	—1.65	2.60	—1.96	3.45	+1.35	3.50	+0.88
Ripley	Sunman	6	2.45	—1.22	3.41	—1.77	4.38	+1.48	4.35	+1.61
Warrick	Dagonia Springs	6	2.92	—1.11	2.88	—1.90	3.06	+1.02	5.10	—0.61
Clark	Blue Lick	12	2.73	—1.86	3.65	—2.70	4.09	+1.46	4.04	+0.18
Central		5	2.33	—0.98	2.82	—1.46	4.19	+1.43	3.80	+1.08
Johnson	Franklin	6	2.45	—1.10	2.68	—1.47	4.04	+0.33	3.80	+2.20
Fayette	Connersville	7	2.55	—1.70	2.32	—1.43	4.47	+2.12	4.37	—0.61
Marion	Indianapolis	18	3.85	—1.70	3.59	—1.47	4.15	+1.61	5.44	—0.76
Rush	Mauzy	9	3.50	—1.80	4.52	—2.44	4.89	+1.20	5.45	—0.75
Henry	Spiceland	35	3.90	—1.82	3.20	—1.52	3.35	+3.08	4.30	+0.40
Wayne	Richmond	6	2.38	—1.53	2.77	—1.95	4.21	+2.54	4.07	—0.33
Randolph	Farmland	6	2.18	—0.46	2.52	—1.45	4.42	—0.27	3.68	+1.91
Delaware	Muncie	4	.....	.....	.....	.....	.....	.....	.....	.....
Northern		5	2.02	—0.14	2.03	—1.15	4.46	+1.24	4.12	+0.61
Tippecanoe	Lafayette	10	2.39	—0.70	2.78	—1.94	4.86	+1.55	4.91	—0.77
Carroll	Delphi	4	1.92	—0.74	2.16	—1.35	5.82	+1.43	.....	.....
Whitley	Columbia City	4	2.01	+0.45	2.50	—1.45	5.17	+0.78	4.46	—0.67
Steuben	Angola	5	2.18	—0.18	2.21	—1.02	4.28	+0.97	4.48	—0.98
State		7	2.37	—0.86	2.70	—1.89	4.22	+1.28	4.16	+0.04

TABLE K.—*Records of rain-fall throughout Indiana during May, 1889.*

Stations.	Counties.		Altitude above sea, in feet.	Latitude north.	Longitude west.	Precipitation. Total for month, including melted snow.	Greatest in 24 consecutive hours. Amount.	Greatest in 24 consecutive hours. Date.	Snow-fall.	Number of days. Cloudless.	Partly cloudy.	Cloudy.	On which rain or snow fell.
Southern:				° ′	° ′				*In.*				
Mount Vernon	Posey	a b	410	37 58	87 54	4.53	3.35	29, 30	T	8	7	16	8
Huntingburgh	Dubois	a	....	38 21	86 59	6.55	3.55	29, 30	0	7	0	24	10
Princeton	Gibson	a	481	38 23	87 35	4.49	1.40	29, 30	0	14	13	4	7
Marengo	Crawford	a	....	38 24	86 24	9.85	5.70	29, 30	0	10	9	12	11
Salem	Washington	c	....	38 38	86 7	5.29	2.76	29, 30	0	14	8	9	10
Vevay	Switzerland	a b	525	38 47	84 59	6.17	2.60	29, 30	0	11	7	13	16
Butlerville	Jennings	a	....	39 3	85 33	6.43	4.02	29, 30	0	16	8	7	13
Worthington	Greene	c	540	39 9	87 0	2.90	1.86	29, 30	0	..	..	..	11
Seymour	Jackson	c	648	38 45	86 31	6.14	3.00	29	T	8	14	9	15
Columbus	Bartholomew	c	....	39 13	85 56	4.80	2.27	29, 30	0	9	10	12	12
Sunman	Ripley	c	1018	39 14	85 6	5.72	2.60	29, 30	0	14	8	9	11
Degonia Springs	Warrick	a	....	38 6	87 12	4.04	1.45	29, 30	0	15	5	11	10
Cannelton	Perry	c	....	37 57	86 42	4.53	1.96	29, 30	0	12	7	12	10
Blue Lick	Clark	a	1000	38 32	85 50	5.55	1.78	30	c	10	10	11	10
Jeffersonville	do	a	....	.....	.....	5.78	3.43	29, 30	0	3	21	7	12
North Providence	do	b c	575	38 25	85 54	4.78	3.27	29, 30	0	10	4	7	11
Mean		..	....	39 30	86 13	5.17	2.62	.....	0	11	9	11	11
Central:													
Franklin	Johnson	a	....	39 40	85 3	4.37	1.88	29, 30	0	8	0	23	15
Connersville	Fayette	a	....	.....	.....	6.59	2.14	29, 30	0	12	4	15	12
Shelbyville	Shelby	..	....	.....	.....	4.65	2.15	29, 30	0	..	..	..	.....
Indianapolis	Marion	a b	766	39 47	86 11	5.76	2.13	29, 30	0	6	9	16	15
Mauzy	Rush	b c	....	.....	.....	6.09	2.79	29, 30	0	..	..	..	14
Spiceland	Henry	a b	....	32 50	85 25	6.43	3.18	29, 30	0	6	20	5	13
Richmond	Wayne	c	969	39 51	84 53	6.75	2.68	29, 30	0	11	8	12	14
Rockville	Parke	c	722	39 46	87 10	5.75	2.60	29, 30	0	18	0	13	12
Farmland	Randolph	a	....	40 11	85 10	4.15	2.44	29, 30	0	8	9	14	7
Muncie	Delaware	a	....	40 11	85 25	.....	..	.....	0	20	0	11	8
Mean		....	....	.....	.....	5.62	2.44	.....	0	11	6	14	12
Northern:													
Lafayette	Tippecanoe	c b	661	40 27	86 55	6.41	1.92	29	0	11	6	14	12
Delphi	Carroll	c	580	40 36	86 41	7.25	3.87	29, 30	0	5	11	15	12
Marion	Grant	c	....	40 34	85 21	3.20	1.60	29, 30	0	..	..	..	7
Columbia City	Whitley	c	....	41 9	85 30	5.95	4.25	29, 30	0	..	..	..	7
Angola	Steuben	a	683	41 37	85 1	5.25	3.85	29, 30	0	10	5	16	7
Lagrange	Lagrange	a	980	41 37	85 26	.....	.....	.....	.....	..	..	..	...
Mean		....	....	.....	.....	5.70	2.91	.....	0	8	8	15	9

SUMMARY.

	Precipitation. Total for month, including melted snow.	Greatest in 24 consecutive hours. Amount.	Greatest in 24 consecutive hours. Date.	Snow-fall.	Number of days. Cloudless.	Partly cloudy.	Cloudy.	On which rain or snow fell.
				In.				
Northern counties	5.70	2.91	.....	0	8	8	15	9
Central counties	5.62	2.44	.....	0	11	6	14	12
Southern counties	5.17	2.62	.....	0	11	9	11	11
State	5.50	2.66	.....	0	10	8	13	11

The wet weather theory here appears broken, and a low temperature is the only element which appears uniformly through the months during which the Grain Aphis was, in all probability, increasing with the greatest rapidity. That cool weather should favor the development of these insects would, if true, be a new factor in the problem, not only of this, but other species also; and before leaning too heavily upon this evidence we should cast about for good reasons for this apparent ambiguity.

There is one very important element in this whole problem which we have so far left out of consideration, viz, natural enemies. While low temperature might not favor the development of the grain Aphis, or in fact, if the effect was slightly adverse, if the outcome was to destroy or retard the development of parasites, the ultimate result would be to favor the Aphis.

For myself, I can not get rid of the feeling that the indirect action of the weather of May and June—the action upon the parasites—was much greater than the direct effect upon the Aphis itself.

According to my field-notes, my earliest observation of the grain Aphis about La Fayette, lat. 40° 27′ N., during any year, was on April 27, and we have observed them during other years on grain early in May, in greater abundance than they were the present year on the 1st of June; yet in the former case no outbreak occurred. Up to the 1st of June, the Aphis was not exceedingly abundant on grain about La Fayette.

Even as late as the 7th their numbers on the heads of wheat were not so much greater than they had occasionally been in former years as to cause alarm; yet within ten days they were swarming in these same fields in myriads. This certainly bespeaks more of the effects of relief from the pressure of parasitism than from the effect of meterological conditions, especially a change from dry to wet weather.

The question may be asked, why, if this be true, were not the parasites destroyed in the southern portion of the State, late in May, thereby relieving the Grain Aphis from this check on their increase, and why the latter by reason of this relief did not, as the wheat became too advanced, overrun the oat-fields, as would have at that date naturally followed. The reply is that such results did follow to a limited extent, the oats being rather more seriously infested by the Aphis than farther northward, and the reason why this feature was not more marked was doubtless owing to the fact that the cold waves of the first and last of May, especially the latter, were less severe than farther north, and the effect on the parasites correspondingly less fatal.

The records of the State weather service show that the minimum temperature of the first four days of May at La Fayette was below the freezing point; and on the 22d, 23d, 30th, 31st, from 34° to 39° Fahr. The mean minimum for the entire State for the same month, according to the same authority, was, for the southern portion, 36° Fahr., for the central 32° Fahr., and for the northern 30° Fahr.

Buckton (British Aphides, vol. 1, p. 70) has the following to say with regard to the effect of weather on this and other species of Aphides:

> Violent changes of temperature seem much to check the multiplication of the Aphides. A cold rain, or the outburst of a thunder storm, will often cause the almost entire extermination of swarms, and wash them, never to return, from their native plants. Nevertheless, the close and hot atmosphere before a thunder storm seems to to be peculiarly suited to their propagation. At such times the winged forms occur in great numbers and take flight on the gentle winds, which transport them many miles to other feeding grounds, to become the foundresses of other colonies.

The effect of the parasites on the Grain Louse was simply astonishing, while their numbers were myriads. Going to the fields of recently harvested grain, if one stood in a position to bring the newly made shocks between himself and the setting sun, he could clearly observe the swarms of minute Hymenopters arising therefrom and flying away. Besides, the stubble-fields were overrun with lady beetles and their larvæ.

Nevertheless, there are good grounds for the belief that the heavy showers during the latter part of June and early July, in the central and northern portions of Indiana, washed many young from the heads of the grain and destroyed them. Besides, either the severe thunder and lightning which accompanied these storms or the rapidly maturing grain, or both, perhaps, caused the winged adults to betake themselves to the oat-fields, where they would probably have caused further damage had not their relentless foes, the Hymenopters, pursued them and continued their work of destruction.

It was a common sight early in July, in northern Indiana, to see adults of the grain-lice attached singly to heads of oats, sometimes with a few young clustered about them, assuming the form and color so indicative of parasitism. In southern Indiana, late in June, the same thing was observed on oats, and parasitized adults were also abundant on the heads of blue-grass, even long distances from grain fields.

In summing up the matter, it may be safely said that wet weather will not, of itself, prevent an outbreak of the grain Aphis, or dispel it after under full headway. It must be borne in mind, however, that cool wet weather, during May and June, will enable grain plants to sustain greater drafts on their vitality than will very dry and hot weather. It is also probably true that a cool temperature during spring and early summer is either directly or indirectly favorable to the development of the grain Aphis.

Regarding the life history of the species under consideration we have never found them in the fields at an earlier date than April 27. From this time we have an unbroken record of their occurrence up to July 9, when there is a break in their continuity of appearance until September 1, when full grown apterous females were found on leaves of early sown wheat. From this latter date we again have an unbroken record up to December 30. We have also observed the sexes pairing on November 11 and December 3.

We have several times attempted to follow the species through July and August, but have always failed. Adults placed on various kinds of grasses in breeding cages invariably died during July. The occurrence of great numbers of wingless parasitized females on heads of *Poa pratensis*, long distances from grain fields, strongly suggest this grass as one of its midsummer food plants. While in this and other cases we have been unable to rear Aphides on certain plants in breeding cages, yet we do not feel at all certain but that outside, under the usual environments, nature might accomplish precisely the same object. The results of breeding cage experiments with Aphides must always be accepted with extreme caution.

The present year we had young grain growing continually from spring to November, yet not a single grain Aphis was to be found on either this young grain or grasses from July 9 to late in October. Their limited numbers at this season may, however, be accounted for by the fact that they were very nearly exterminated in July by their natural enemies.

Dr. Cyrus Thomas states that in 1875, in Southern Illinois, he observed winged and wingless specimens on wheat during winter, and suggests that the species winters over in other forms than the egg.* There appears to be no good reason for doubting the truth of Dr. Thomas' suggestion, especially if applied to mild winters. During the time we have been located in a wheat-growing district the winters have been quite severe, so that we have not been able to follow the species through the cold months. The winter of 1888–'89 was a mild one, but we were absent in Australia during the entire time.

Siphonophora avenæ is by no means the only species of Aphides infesting the plants of our smaller cereal grains. An undescribed species of *Toxoptera* occurs on the leaves of wheat in the latitude of La Fayette, in June. We have carried this species through July and August on wheat in breeding cages, found it again in the fields in September, and from this on until the 22d of December. During the latter month they continued to reproduce in a room, which, though warm during the day, the temperature fell below the freezing point every night. I have not been able to follow the species through the winter months in the fields.

A species of *Aphis*, undistinguishable from *A. mali*, appears regularly every September, and, indeed, sometimes as early as July 17, on young wheat and rye. From the latter date up to the 12th of November they have been observed on young grain, giving birth to their young.

Notwithstanding the fact that the species is not distinguishable from the apple tree Aphis, yet the attempt to transfer them to the apple leaf, or vice versa, has invariably resulted in failures.

A second *Aphis*, as yet undescribed, is found about the roots of wheat, often in sufficient numbers to affect the plants. This species occurs throughout the entire State, from about the last of September, and

*Eighth Rep. St. Ent. Ill., 1879, p. 53.

probably winters over in the fields, in other stages besides the egg, al though we have never yet found them on grain during the early part of the year.

An undescribed species of *Rhopalosiphum* was found on spring grown volunteer wheat, on July 12, of the present year. A few days later adults, both winged and wingless, and young in all stages of development, were found on the heads of orchard grass, *Dactylis glomerata*, and also on the heads of spring sown rye, working precisely after the manner of the true Grain Aphis. This species I was not able to follow in the fields after about the 10th of August, when it left the heads of rye, and, though a large number were placed on young wheat plants, in a breeding cage, all seem to have died.

When this last species was confined on wheat, the same cage and plants were utilized as had been used in the attempt to carry the true grain *Aphis* through the months of July and August. But as none of the many individuals placed on the plants survived, a large number of heads of rye thickly infested by the *Rhopalosiphum* were placed in the cage. When the first winged adult appeared in this cage, I was not a little surprised to find it belonged to neither one of the species intentionally placed in the cage, but to a species of *Myzus*, which could have only gained admission by being introduced with one or the other or both of the other species.

By whatever way it gained admission, this *Myzus* has continued to throw off generation after generation, and at date of writing, November 25, is still reproducing, although during the entire time—nearly four months—it has had no other plants except wheat upon which to subsist. It is undescribed.

Still another species (a *Megoura* sp.?) was found giving birth to young, on leaves of young rye, August 9, but not observed afterwards.

The natural enemies of the Grain Aphis were, as we might expect, unusually numerous the present year, and especially those belonging to the *Hymenoptera*. Of these we had reared, during other years, a species of *Trioxys* in quite abundance, and this season the following occurred in great numbers: *Bassus sycophanta* Walsh, *Aphidius avenaphis* Fitch, *Isocratus vulgaris* Walker, *Encyrtus websteri* Howard, *Allotria tritici* Fitch, *Megaspilus niger* Howard, *Pachyneuron micans* Howard.

Of the Syrphids, *Sphaerophoria cylindrica*, *Xanthogramma emarginata*, and *Allograpta obliqua* were very numerous. A secondary parasite, *Bassus sycophanta*, was in some localities so exceedingly abundant that nearly all of these useful flies were destroyed.

Two species of Chrysopa were exceedingly useful. In a field of wheat, near Indianapolis, about the middle of June, these were so abundant that at every step, from one to four or five individual adults would be disturbed, and take wing. The field was but very slightly attacked by *Siphonophora*.

Of the Coleopterous enemies, the *Coccinellidæ* were by far the most industrious. Of this family probably *Coccinella 9-notata*, with its larvæ, was the most abundant and generally distributed species.

In a field of newly harvested grain, in La Grange County, within a radius of 3 feet from where I was standing at the time, fifteen individuals were counted, crawling about among the stubble. *Hippodamia parenthesis* followed next, in point of numbers, *H. convergens*, *H.* 13-*punctata* and *H. glacialis* being also found in quite large numbers in various localities. *Megilla maculata* was scarcely noticed at all, and *Anatis* 15-*punctata* but once.

Podabrus tomentosus was exceedingly useful in some portions of the State, while *Telephorus carolinus* was often quite numerous in the fields of the central part of the State.

ENTOMOLOGICAL NOTES FROM MISSOURI FOR THE SEASON OF 1889.

By Mary E. Murtfeldt, *Kirkwood, Mo.*

LETTER OF SUBMITTAL.

Dear Sir: I inclose herewith such of my notes and observations on insects as may be of economic interest, and in this connection desire to express my sincere thanks for determinations and other assistance, for which I am indebted to yourself and to others of the official force of the Division.

Yours, very respectfully,

Mary E. Murtfeldt.

Prof. C. V. Riley,
U. S. Entomologist.

GENERAL OBSERVATIONS.

The Cabbage Curculio (*Ceutorhynchus rapæ*).—A number of my correspondents in the central part of the State have informed me of the serious ravages of this insect in their hot-beds and vegetable gardens. Mr. F. M. Webster also wrote me, about the middle of May, that it had appeared in his garden in La Fayette, Ind. As yet I have not found it in Kirkwood or vicinity, and as it was with some difficulty that I obtained specimens for study, I have not been able to make such tests of insecticides upon it as would be practicable in the field. It promises to become a general and very considerable pest to the market gardener.

The Wavy-striped Flea-beetle (*Phyllotreta vittata*).—This insect appeared in great numbers this year in all parts of the State, being very destructive to peppergrass, early radishes, turnips, cabbage, and other *Cruciferæ* during the months of April and May. Mr. S. W. Gilbert, of Thayer, in the extreme southern part of the State, reported a loss of over fifty thousand cabbage-plants from the work of the larvæ on the roots. I could scarcely credit the statement that such extensive injury was attributable to this one insect until convinced by specimens of the pest, and of the injured plants which were excoriated and channeled on the surface of the roots from collar to tip, the foliage also being injured

by the mature beetles. A top-dressing of wood-ashes with a slight admixture of Paris green was recommended, but I was not informed with what results.

In company with this flea-beetle on the leaves of late radishes in our own garden, I was surprised to find great numbers of a species of *Podura*. I could not determine whether it produced any effect on the radish foliage independently, or why it should have appeared there so numerously.

Canker-worms (*Anisopteryx vernata*), except in orchards thoroughly plowed and harrowed the previous autumn, were quite abundant. Owing to the very warm winter, and consequent irregularity in emergence of the moths, cotton band traps, applied even as early as the first of March, did not capture as large a proportion of the females as usual. On some trees, therefore, the worms were numerous and where not killed by spraying were quite injurious.

The Plum Curculio, which last year caused scarcely any damage to the fruits usually affected by it, appeared this season with recruited ranks; and on peach and plum trees, where spraying was not practiced, or where the frequent rains washed off the arsenites, a large proportion of the fruit was stung. As confirmatory of the single broodedness of the species, I observed that all the very late peaches, whether free or cling stones, even when so severely punctured on the surface as to prevent the development of the fruit, were entirely free from worms, showing that the cuts had been made for food only.

Aphididæ.—It would seem as though all known and unknown species of this group of insects appeared in myriads throughout the Mississippi Valley, during the spring and summer. In many instances trees and shrubbery were killed outright by the punctures of their countless beaks, and the closing of the stomata of the leaves by their sticky exudations. So badly infested were the elms, maples, lindens, box-elders, and other shade trees, in and around Minneapolis, Minn., during the latter part of June that to pause or even pass beneath them was to endanger one's apparel from the honey dew that continually dripped from them, and from the black mold that soon covered trunk and branch and which "smutted" everything touching it. All other insects seemed to be repelled from the aphis-infested trees; not even a leaf-roller or leaf-miner could I see. In the September number of INSECT LIFE, mentioning the prevalence of *Aphis avenæ* in the grain-fields of many of the Middle and Western States, I observe that Missouri was omitted from the list. The insect, however, occurred quite extensively in the middle and northern portions of the State, but it appeared rather late, and but comparatively little damage was done so far as I have been able to learn.

Syrphus fly, Coccinellid and Chrysopa larvæ waged a fierce, but, at first, unequal warfare with the tiny hosts, assisted by *Aphelinus* and probably other smaller as well as larger allies, so that as the season

advanced the *Aphididæ* gradually disappeared and where seasonable rains followed the unfortunate plants measurably recovered, though the growth of trees and shrubbery was much retarded and distorted by them.

Codling Moth, not seriously destructive in the northern part of the State, but in the vicinity of St. Louis and in the southern counties, as I have been apprised by various correspondents, fully 50 per cent. of the fruit, on trees not sprayed, was destroyed by it.

The Stalk-borer (*Gortyna nitela*) committed its usual depredations in the leaf stalks of rhubarb and in shoots of blackberry and peach. Mr. S. W. Gilbert wrote me that it was so abundant in his young peach orchard that in the course of one walk among the trees he cut off twenty-five or thirty bored shoots. He says:

> The worm seems to enter at the second or third bud from the tip and bore through the heart as far as the body of the tree but does not enter the hard wood.

In the flower garden this insect has done considerable damage by boring the stalks of dahlias, cosmos, and other flowers.

The Flea-like Negro-bug (*Corimelæna pulicaria*).—Mr. E. S. Pollard, of Cameron, northwest Missouri, under date of May 22, sent specimens of this insect with the information that they were very abundant in his strawberry beds, and doing much damage by puncturing the bearing stems, causing the fruit to shrivel. As it was the fruiting season, I was at a loss to suggest a remedy, since this insect is not susceptible to the effects of pyrethrum, or other non-poisonous applications. In Kirkwood it appeared in great numbers on hollyhocks and various other flowering plants, for which the easiest remedy seemed to be to jar it into basins of soap-suds to which had been added a small quantity of kerosene.

Lygus lineatus appeared here and there on tufts of clover, about the middle of May, injuring the foliage to considerable extent. It inhabits the under surfaces of the leaves which it speckles with transparent dots and small patches which cause the leaves to curl and shrivel. Its broad, flat larva is of a dull, pale green color, variegated with a few ferruginous marks and shadings. The pupa is very similar, with the addition of the wing-pads.

The Tarnished Plant-bug (*Lygus pratensis* Linn.).—This insect was more abundant than usual throughout the State, and from numerous correspondents I received bitter complaints of its injuries to apple and pear buds and to strawberry beds. During the autumn it appeared in considerable numbers on chrysanthemums, on which its peculiarly poisonous punctures produce most disastrous effects. I was quite successful in driving it from our own plants by liberal applications of X. O. dust, which proved at the same time a good remedy for the brown aphis, which is such a common and unmanageable pest on these beautiful flowers. The plants were not injured in the least by the insecticides.

The Streaked Cottonwood beetle (*Plagiodera scripta*) appeared in our grounds during June on a young *Populus*, which it threatened to completely defoliate. The tree being small admitted of thorough drenching with a plant syringe with the solution of arsenic and ammonia—1 ounce of arsenic in 1 quart of aqua ammonia—1 tablespoonful of the solution to a gallon of water, by which means and a little hand-picking the pest was so thoroughly exterminated that it did not reappear later in the season.

The 12-spotted Diabrotica (*D. 12-punctata*) was a serious pest during the latter part of the season, not only on squash and cucumber vines, but on late sweet-corn, and especially in its injuries in the flower garden on the blossoms of roses, dahlias, and cosmos on which it literally swarmed. To save the flowers it was necessary to make the rounds two or three times a day and capture or put the beetles to flight. They were not much affected by any of the milder insecticides, and the arsenical remedies could not very conveniently be applied.

The European Cabbage-butterfly (*Pieris rapæ*) acquires one or more new food plants annually and threatens to become quite omnivorous. This year it proved in several localities very destructive to nasturtiums (*Tropæolum*) both in flower and vegetable gardens. None of its parasites have yet appeared, so far as I have been able to ascertain. It seems to have entirely supplanted our native *P. protodice* in this locality. Wishing to obtain some larvæ of the latter for a certain purpose, I made many examinations during the summer of the neighboring cabbage plantations, but did not succeed in finding a single one.

SPECIAL STUDIES.

The Spinach Beetle.

(*Disonycha collaris* Fabr.)

About the middle of April I observed the leaves of spinach in the garden were badly perforated, and, upon examination, I found on the under surfaces numbers of small, dingy, white larvæ, evidently of some Chrysomelid beetle. They reposed in the numerous depressions between the veins, and a slight shake or jar caused them to drop to the ground. The insects increased in size and numbers until by the middle of May all the leaves were badly injured and the gardeners hereabout complained that their spinach was so "worm eaten" this year that they could no longer offer it for sale. A few of the same larvæ were also found on young beet leaves, especially of the white and yellow varieties, and upon the wild *Chenopodium album*, the latter being, I suspect, the original food plant of the insect.

As the larvæ drop so quickly upon being disturbed, it is not often that they are observed by the gardener or cook, and the damage was attributed by many to "some kind of cut-worm." By plucking the

leaves, carefully, however, as many as fifteen or twenty "grubs" were sometimes found on a single leaf.

April 24 I collected a large number, which were placed in a jar in order that their development might be more closely watched. Most of these were still very small, only from 3 to 4^{mm} in length. When very young they merely gnaw the under surface of the leaf, noticeable on the upper side as small discolored spots, but as they increase in size they eat entirely through both cuticles, making large roundish perforations.

It is probable that there are but three larval molts, as, in the case of even the smallest larvæ under observation, I was able to note but two, and infer that one had been passed before they were brought in.

The larger larvæ entered the ground the 4th, 5th, and 6th of May, penetrating to a depth of only from one-fourth to one-half an inch and inclosing themselves in frail, nearly spherical, cocoons or cells of earth cemented with a viscid secretion. Larvæ, however, were found on the spinach throughout the month of May.

May 25 one of the beetles emerged, which proved to be *Disonycha collaris* Fabr.; and from this time until after the middle of June bred specimens continued to come out.

A package of specimens was sent to the Department in case it should be considered desirable to have drawings made of the different stages of development. Unfortunately this consignment did not reach Washington, and I did not learn of the failure until too late to replace it. Specimens were, however, preserved in alcohol, which retain all the important characters.

No account of the immature stages of the insect or of its spinach-feeding propensity is to be found in any work on economic entomology to which I have access, and I think it has not heretofore been recognized among the pests of the vegetable garden. I therefore subjoin the following descriptions.

Egg, not observed.

Mature larva, from which the young differ only in size, 9^{mm} in length, 3 to 4^{mm} in diameter; form subcylindrical, tapering slightly each way from middle segments, which, both in resting and crawling, appears somewhat elevated or "hunched up." Color a dirty, rather livid white, with a shiny, slightly viscid surface, each segment produced with ten conical papillæ—lateral ones largest—each of which terminates in a minute bristle. Head about one-half the diameter of the thoracic segments, oblique, circular, corneous, fulvous, paler in front, with dark brown mouthparts and two dark brown, somewhat elevated, spots on each side. The posterior end of the body terminates in a dark brown, corneous wing, most pronounced on the dorsal side, fringed with bristles. This is always appressed to the leaf, and in moving the bristles assist in propulsion. Legs concolorous with general surface, but with fulvous or dingy brown annulations, the terminal joint being entirely of the dark color.

Pupa, 8^{mm} in length, 3 in diameter across dorsum, with elytra and wings partly extended as in other pupæ of *Halticinæ;* the legs drawn up and folded close against the body. Color pearly white in all its parts, acquiring a translucent gray tinge before the last transformation.

Beetle quite pale at first, gradually acquiring the dark metallic green of the elytra, buff thorax, dark legs and under surface and other colorational characteristics of the mature insect.

This species seems to be but single brooded, as no young larvæ were to be found after the first of June. As, however, the spinach beds were rooted out before midsummer in all the gardens of the vicinity, I can not be quite certain upon this point, but could not discover it on beets or any of the native *Chenopodiaceæ*. The insect is one to which it is difficult to apply insecticides, as the leaves which it attacks lie close to the earth and it is, as a rule, on the under side.

New Rose Slug.

(*Cladius isomera* Harris.)

Early in August a friend, residing at St. Charles, Mo., sent me specimens of a Tenthredinid larva that was working on her rose bushes, especially on climbers. This species, new to me, devours the entire substance of the leaves, gnawing into them large ragged holes and webbing them together in the formation of its cocoons, greatly injuring and disfiguring the plants. It is characterized as follows:

Mature larva 12^{mm} in length, 3^{mm} in diameter across thorax, from whence it tapers very slightly backward; form cylindrical. Color, pale bluish-green, surface clothed with tufts of soft gray hairs. Head opaque, dull whitish green, under the lens densely mottled with pale, ferruginous, small black dot, above which is a rectangular ferruginous spot on each side. Twenty legs, concolorous with general surface. Spins up between folded leaf or between two leaves, in glassy, gummy, pale brown cocoon, 7^{mm} long, of an oblong shape, flattened on both sides against the inclosing leaves and with many gummy threads spreading in every direction.

Cocoons were formed in rearing cage August 20. Flies appeared August 29. On the 2d of September I detected two in the act of ovipositing, with their well-developed "saws" deeply buried, one in the midrib, the other in the petiole of a fresh leaf. Two or three minutes were occupied in the placing of an egg and each fly put in three or four without pausing to rest. By carefully detaching the surrounding fibers the egg was revealed. It is oblong, scarcely 1^{mm} in length, and almost transparent. These eggs failed to hatch, probably for lack of fecundation.

From what I have learned from my friend, and infer from the habits of the insect in the rearing cage, there are an indefinite number of broods during the summer, and where it has become established it is therefore a more serious pest of the "queen of flowers" than even *Selandria rosæ*. I do not doubt, however, that by killing off the earliest broods with drenchings of an infusion of white hellebore, it could be kept in check and by perseverance in the treatment eventually exterminated. I have not been informed of its occurrence in any other part of the State.

The White Fringe Slug.

(*Selandria* ? sp.)

The White Fringe tree (*Chionanthus virginica*), in its season one of the most exquisite of flowering shrubs or small trees, is subject to the annual attack of a medium-sized, spiny slug that perforates the leaves with small round holes after reducing the greater number of them to mere lace-work. This species is single brooded, but the parent flies appear irregularly and larvæ may often be found from the latter part of April until the end of May, in the interval seriously disfiguring, often killing, the foliage. It lives on the under side of the leaves and feeds chiefly at night. Full grown larvæ from 9 to 12^{mm} long, 3^{mm} in diameter across the thoracic segments, form cylindrical, nearly equal throughout, or tapering slightly backward from thorax. Color greenish-white, surface very rugose, dorsum and sides quite thickly beset with bifid spines, those on dorsum jet black, arising from velvety black spots and being largest in the subdorsal region; lateral spines pale. Head about one-half the diameter of thorax, almost spherical, jet black, immaculate. Legs, 22 in number, concolorous with general surface, and unusually well developed. With me it has proved a difficult species to rear, and I confined the larvæ for several successive seasons without getting a single fly, and last spring but two from a large number of larvæ developed. In the rearing cage, after ceasing to feed, the larvæ desert the leaves and wander restlessly around the cage, many of them dying without entering the ground. The few that transform inclose themselves in very brittle, nearly spherical cells about an inch below the surface, and as with most other saw-fly larvæ that enter the ground brook no disturbance during the quiescent period. The two flies that I succeeded in rearing came out about the middle of April.

Syringing the under sides of the leaves with a strong infusion of white hellebore, or with Paris green in liquid suspension, will kill the pests, with but little detriment to the foliage.

Description of the Larva and Pupa of Palthis angulalis.

Among the insects trapped last spring in loose cotton around the trunks of apple trees were a considerable number of a dingy-colored noctuid larva, about 1 centimeter in length by 4^{mm} in diameter, of nearly equal width throughout, the segments appearing somewhat hunched together. Surface rough, of an earthy-brown color, palest on dorsum. Under the lens, especially after being dropped in alcohol, a tinge of green appears, and the paler cast of the dorsal surface is resolved into a spreading V composed of minute white stippling. This is especially pronounced on the posterior segments, where the angle of the V is developed into a papillate elevation. Head small, much retracted, dark brown; legs and prolegs, and also to some extent the entire ventral surface, verdigris green. These larvæ were found from the 1st to the 5th

of April, and, when placed in the cage with opening apple buds, nibbled a little, but almost immediately changed to pupæ within a cluster of webbed leaves. Pupa smooth, dark brown, without any especially distinguishing characters. Three imagines appeared April 24. They were of a species which had been long before determined for me as a *Palthis angulalis*.

With the idea that possibly the immature stages of this insect had not previously been observed, I submit the above descriptions.

INSECTICIDES.

White arsenic in ammoniacal solution—1 ounce arsenic to 1 quart aqua ammonia—one tablespoonful of this to a gallon of water proved a failure in the case of most insects, while it still scorched the leaves somewhat.

A soda solution made on a smaller scale had much the same effect on the foliage of peach and plum trees, and was not, so far as could be observed, efficient in protecting the fruit from curculio.

White arsenic in boiling water, the latter being only a partial solvent, in the proportion of an ounce of arsenic to 20 gallons of water, was sprayed upon young peach and plum trees without injury to the foliage. The frequent rains of the late spring and early summer rendered many of the applications futile in the case of the curculio and codling moth. Paris green in liquid, 1 pound to 100 gallons of water, has been found the safest and most reliable insecticide for use against the canker-worm and codling moth. Its effects on insect life seem to be due not alone to the percentage of arsenic, but to the general combination, while on vegetation it produces less injury than London purple or any of the solutions of pure arsenic.

In my somewhat limited experience the petroleum emulsions can not be excelled as a remedy for all species of scale insects, and when applied according to instructions, do no appreciable injury to trees and shrubs.

X. O. Dust.—Late in May I received from the Department a package of this new patented insecticide, with instructions to test its value on various injurious insects. It is to be applied full strength and claims to kill by contact and at the same time to be innoxious to man and the higher animals and to vegetable life.

June 1.—Applied the powder about 9 o'clock in the morning to *Doryphora* larvæ on potato, to late specimens of the rose-slug (*Selandria rosæ*), to *Aphis persicæ* on young peach and plum trees, and to Aphis sp.? on chrysanthemums; also to young cabbages and radishes, on which flea beetles (*Phyllotreta vittata* and *zimmermanni*) were abundant and destructive. Three hours later visited these plants and noted following results: Rose-slugs considerably affected, showing symptoms of sickness and paralysis and dropping from the leaves when jarred. *Doryphora* larvæ not seriously affected, only the smaller ones had dropped, while some of those nearly grown continued feeding, appar-

ently not inconvenienced by the dust that adhered to them. Flea beetles not killed, but evidently demoralized and deserting rapidly. Its effects on *Aphididæ* were quite satisfactory. All species to which it had been applied seemed to be killed or paralyzed and had withdrawn their beaks from the stems or leaves, and if they had not already fallen did so upon the slightest jar. At the same time *Chrysopa* and *Coccinellid* larvæ appeared but little, if any, injured, and were seen making their way to other hunting grounds on which the game should not be so pungently spiced. Syrphus-fly larvæ, however, did not escape, and all that received much of the dust were killed.

At 7 in the evening more of the powder was distributed on infested potatoes and on all species of Aphis that could be reached.

June 3.—The effects of the Dust on the Colorado potato-beetle are by no means so immediate and thorough as claimed in the circulars of the manufacturers. Repeated applications would seem to be necessary to kill the larvæ, while according to my experience the perfect beetle will live for days thoroughly dusted with the powder and inclosed in a box. At the same time it certainly does protect the plants to which it is applied, especially while fresh, by acting as a repellant.

September 10.—Tested the Dust on larvæ of the cabbage butterfly which are beginning to be found again in cabbage fields. Used the insecticide in the open air, also on a few full-grown larvæ placed in jar, under muslin cover.

September 15.—Plants dusted seem almost entirely free from worms, but several of the larvæ confined completed their first transformation without apparently receiving any injury from the powder.

September 21.—Repeated these tests with powder taken from the bottom of the can and found that young *Pieris* larvæ succumbed to its effects in two or three hours, while the larger larvæ often lived more than twenty-four hours, not eating, however, in the mean time, but lingering in a lethargic state until dead.

October 19.—Renewed these experiments on the latest brood of worms which are now to be found of all sizes on cabbages, turnips, and nasturtiums. The immediate effect of the powder is to cause the larvæ to cease feeding and toss themselves about uneasily, making efforts to free themselves from the irritating substance. Two hours later all were in a lethargic state, many lying upon their sides in the folds of the leaves and on the ground. They would squirm when touched, but gave no other sign of life. Twenty-four hours later all the small larvæ were dead; the others that had passed the second molt still lived, but were inactive with a sickly color. Forty-eight hours afterward all were dead. From these tests and experiments I conclude that this X. O. Dust may be classed with reliable remedies for this and probably other Lepidopterous cabbage pests, its value being nearly equal to that of Pyrethrum powder.

This remedy was also used on Tarnished Plant-bug with the effect of

driving it from the dusted plants, although bugs confined in a box with it would survive several days.

The little *Halticus pallicornis*, which was this year very troublesome, not only in the clover fields and vegetable gardens, on beans, cucumbers, etc., but was especially destructive to asters, was also routed by having this powder puffed on the under side of the leaves; the young bugs were killed and the mature ones driven away.

The Dust was further tested on a few late cut-worms, *Agrotis saucia*, *Celæna renigera*, and some other species which I can not name, but without much effect, as the powdered worms in the course of an hour all crawled out of the deep box in which they had been confined and escaped.

All hairy larvæ, as in the case of Pyrethrum, seemed insensible to its effects, so also did the striped and twelve-spotted cucumber beetles and other mature Coleoptera and the squash-bug.

There are quite a number of injurious insects on which I did not have opportunity to use it, and on which I hope to experiment with it another season.

From my experience with it this season I should rank it among the second-class insecticides, producing similar effects, but not quite equal to the California Buhach, but still valuable for use against certain insects on which it is not safe or expedient to employ the arsenates.

NOTES ON PHYLLOXERA RILEYI FOR 1889.

June 15.—Received instructions through Mr. Howard to collect and prepare specimens of *Ph. rileyi* in all its stages in fluid and in balsam on microscopic slides.

The post-oaks (*Q. obtusiloba*), on which the insect chiefly occurs on the place, were found to be less abundantly infested than during other years. The first leaves which have attained their growth and are beginning to toughen are, however, considerably speckled with their punctures, especially along the midrib and principal veins. Very few besides the pale yellow, smooth, elongate forms are noticeable.

Put up a number of infested leaves in alcohol reduced about 60 per cent. with water. (These I afterwards learned from Mr. Howard did not keep, the alcohol being perhaps too strong). I also prepared slides.

July 22.—Have just returned from Minnesota. Sent slides on to Washington. Examined leaves of post-oak around home, but found no winged *Phylloxera*, and very little change in the specimens on the leaves during the last month.

Among other insects preying on the aphis is *Œcanthus latipennis* in noticeable numbers, one or more on the under side of nearly every leaf. They are now nearly full-grown larvæ. The puzzle is how they come to be on the oaks, when I have never found their punctures in the twigs and when some of the trees are at quite a distance from raspberry or grape vines, in which they mostly deposit their eggs.

July 29.—After driving about the country in several directions I

found on the roadside about a mile from town some post-oak sprouts on which *Phylloxera* abounded in all stages of development. The pale smooth variety was most numerous on the older and tougher leaves, while the darker, tubercled larvæ and pseudo-pupæ and a few winged specimens crowded the unfolding second growth. The young leaves were much curled and distorted by their innumerable punctures. The aphids were preyed upon by the larvæ of the green *Chrysopa* and of one or two small Coccinellids; the deep red larvæ of a small Thrips was especially active and numerous among them, as also was the whitish gray larva of a small bug (No. 3 of my consignment of October 2).

Put up specimens on slides and sent some alive to Mr. Howard in tubes; also some in alcohol. I also placed winged individuals in three different sizes of tubes and on clean leaves in water in a glass jar.

August 3.—Notwithstanding all my care all the winged lice perished without leaving any eggs, to my great disappointment. Probably the extreme heat of the weather was unfavorable. Cleaned and disinfected my tubes and put in fresh winged forms and closed the tubes with loose cotton instead of cork to prevent excess of moisture.

August 3.—Another failure. All the specimens dead and molded and no eggs. I can not understand it.

August 15.—Made another excursion out into the country and succeeded in obtaining a very few. Nearly all the young oaks so badly infested two weeks ago are entirely cleared, probably by the migration of the winged forms and the destruction of eggs and wingless forms by predatory insects. The tender shoots are also killed and stand up stiff and dry; the drought being severe, there was no opportunity for them to recover from the attacks of the aphis.

On the lower mature leaves the insect still abounds in its wingless forms, mostly the flat, pale, smooth variety. Put seven of the winged aphis into a very small tube with a bit of mature oak-leaf and closed it tightly with common cork. (The rubber corks kill all insects inclosed with them very shortly, probably with their sulphurous emanations.) Also put about a half dozen on growing sprouts of oak, out of doors, but which seemed to be entirely free from infection, inclosed under fine muslin cover.

August 17.—Have at last succeeded in getting nine eggs in the small tube. These eggs do not differ much from those of the ordinary apterous form. On close comparison they seem rather more opaque and of a deeper yellow tint than the latter, but even in these particulars there is some variation. Each individual produces from one to three eggs; and usually perishes beside them.

August 21.—Eggs still healthy and beginning to show segmentation with two red eye-spots on the cephalic end. There is evidently a slipping backward of the thin pellicle that incloses them, although as yet no motion is discoverable. The eggs were all laid on the glass and not on the portion of the leaf inclosed with them.

August 22.—Three *Phylloxera* have hatched from the eggs and one

has crawled quite a distance. The egg-shells or pellicles are left as an almost transparent round dot at the place of hatching. Nearly all the substance of the egg seems to be absorbed into the young aphis. Inserted a bit of fresh young leaf, but they do not seem to be attracted to it, and remain crawling on the glass.

August 23.—Two more have hatched. They appear all alike so far as can be ascertained with a lens. Three were sacrificed for microscopic examination. Have the specimens under almost constant observation, but am not able to find them pairing or exhibiting any sexual attraction. Neither can I induce them to feed on even the tenderest bits of leaf. They appear precisely like the parthenogenetic forms through my lens, which is not sufficiently powerful to resolve the mouth parts and genitalia.

September 1.—Only two still alive and no eggs. Transferred the survivors as carefully as possible to fresh leaf and placed in clean tube.

Examined inclosed leaves out of doors but could detect neither eggs nor larvæ. It is an almost impossible task to keep track of such microscopic creatures in the open air.

The wingless lice have now become quite abundant on all our post-oaks. I do not find them on the white oak proper, but as I have examined them almost daily since the middle of July I am confident that none of the winged individuals occurred on any of the oaks on the place. I believe they never do occur in any numbers except on the more succulent growth of sprouts where living trees have been cut.

September 10.—All my progeny of winged lice have perished without leaving a single egg. Made another excursion into the country but obtained only two or three winged individuals which I put in tube, but of which I do not entertain much hope.

On one of the leaves out of doors, isolated about a month ago, I find by critical examination a very few minute specimens which are probably the progeny of the winged forms inclosed. Put some in balsam, though I can not see that they differ from the other wingless young on exposed leaves.

September 15.—No success with the last inclosure in tube.

October 25.—Have had one or two quite hard frosts. Leaves all turned in color, and *Phylloxera* becoming very active, congregating along principal veins and migrating on to the twigs. Their insect enemies have mostly disappeared and I notice that eggs are more plentiful than usual on the leaves.

From my observations this year I incline to the opinion that the winged form is necessary merely for the spread of the species, and that the young from the eggs of this form are not necessarily true-sexed individuals, although it is possible that these may occur without any especial regularity from the eggs of both winged and wingless forms.

Another year, if nothing happens to prevent, I will try to have some oaks in flower pots for more convenient and natural colonization of the *Phylloxera*, and for greater ease in examination.

REPORT ON CALIFORNIA INSECTS.

By Albert Koebele, *Special Agent.*

LETTER OF TRANSMITTAL.

Alameda, Cal. *October* 25, 1889.

Sir: I herewith submit my report upon observations made and work done since my return from Australia.

After returning to Alameda on April 15, some time was taken up in writing out my reports upon work done in Australia, and also in assisting in raising and distributing in the northern part of this State the Australian Ladybird-enemy of the Icerya. This Ladybird does remarkably good and speedy work everywhere. As usual my chief work has been the breeding and studying of all insects, injurious and otherwise, that have come under my notice, the special notes on which will accompany material that will be sent in.

Respectfully,

Albert Koebele.

Prof. C. V. Riley,
U. S. Entomologist.

THE MADRONA TREE BORER.

(*Polycaon confertus* Lec.)

This destructive beetle occurs to a greater or less extent every spring and summer upon various fruit-trees, vines, etc., boring into the fresh wood and destroying it. During my stay in the Santa Cruz Mountains the past summer they were observed everywhere, and most abundantly during May and June. On any dead tree, as soon as the leaves begin to fade, this beetle may be found, though always most abundantly upon the Madrona tree (*Arbutus menziesii*). Old trees of this species, such as have been allowed to lay on the ground for a year or two, are always completely perforated with holes from which these beetles have made their exit. In cutting through, one finds the wood nothing but mines produced by the larvæ, the mines generally running lengthwise, but often crossing each other. The Madrona tree seems to be the ordinary if not the only plant in which the beetle breeds. Notwithstanding that the mature insect bores in almost any kind of fresh wood, and especially favors such as has been somewhat injured by the hot sun, the larva is

not, or has never yet been, found in such places. It is the general belief here that it breeds in the wood of Oak, yet, so far as my experience goes, its larvæ are never found in other than the Madrona wood. It is very remarkable, in view of the above, that they should live and transform within apples from which this beetle has been bred.

On August 2, 1887, at St. Helena, Cal., a large number of the nearly grown apples upon trees in a private garden were observed to be dead and yellowish brown. One of these, taken to Alameda and examined, proved to contain a small whitish Coleopterous larva. This was living and thriving on the dead and dry apple until April 16, 1888, when it transformed to a pupa, from which the mature beetle issued on April 28. Since then no infested apples have been observed, nor have I seen any of the large fruit in the condition described above. The work of these beetles was witnessed in the Santa Cruz Mountains May 25, 1888, chiefly upon grapes and plums, yet they will attack olives and other trees as well. In many cases the shoots of grapes are cut off entirely and fall to the ground, where either one or both sexes may be found at work. In one case I noticed a plum tree the northern branches of which were entirely destroyed. The beetle will often make several holes into the center of a branch before entering; no doubt being compelled to leave on account of the copious flow of sap. Seven such holes were found in one branch, in the lowermost of which the beetle had entered and formed a tunnel of about 3 inches in length. On the other branches, aside from the many holes started, but two tunnels were found and no insects were present. This will show that one of these beetles alone is capable of disfiguring an entire tree, while two or three specimens can destroy a tree.

As a remedy, the recommendation of clearing and burning the dead Madrona wood alone would certainly have a most remarkable effect in reducing the numbers of this beetle.

(*Chrysobothris mali* Horn.)

The larva of this Buprestid is very destructive to currant bushes. It is found in the Santa Cruz Mountains, at least in such numbers as to destroy all the plants. Indeed, it is impossible to raise this fruit in that district on account of this insect. They have not been observed as yet in the valleys, where in their place *Ægeria tipuliformis* Linn. is more numerously represented upon this plant than in the hills. As many as fifteen or even twenty Buprestid larvæ may be found within a single plant, the stems of which naturally die and break off near the ground. The beetle is found most abundantly during June and July, when they can be seen resting on the plants generally near the ground during sunshine. It is then that they lay their eggs on the lower part of the branches and close to the ground where most of the larvæ are found. Eggs are also placed at a height of 2 feet, or even more, according to the size of the plant, and below the ground to the depth of

several inches. Where the larvæ are very numerous the plants will die before the larvæ are grown, and most of the latter will perish; only such as are situated near or below the ground will survive. Empty pupæ of two species of parasites were observed within the burrows of the larvæ, both apparently belonging to the Ichneumonidæ.

As a remedy, the collecting of the beetles may be recommended. During early morning and evening they may be found either on the currant bushes or the surrounding trees, almost always at rest on and within dry and dead leaves from which they can be shaken into an umbrella. During their operations upon the plants in the day-time it is difficult to get near them as they are very quick on the wing and exceedingly shy. Collecting and burning the infested plants during winter, and also the whitewashing of lower parts of plants may have a good effect; this should be done about the end of May.

(*Diabrotica soror* Lec.)

This beetle occurs occasionally in such numbers as to become exceedingly destructive to fruits and vegetables. As yet the earlier stages have not been studied. All attempts to get eggs and larvæ have so far been a failure on my part as well as on the part of other entomologists. A large number of the beetles were kept in confinement for weeks with various living plants without any results. The larva, without doubt, will be found to have the same habits as the other species of the the group,—feeding upon roots of various plants. Fortunately this insect is preyed upon by a dipterous larva, which without doubt destroys the greater number of them, in certain years at least. As early as 1886, while at Los Angeles, Mr. Alexander Craw, of that city, showed both Mr. Coquillett and myself the larva infesting this beetle. I did not succeed in breeding the same until June last, and Mr. Coquillett reports recently of his partial success in this particular.*

THE TENT-CATERPILLARS.

(*Clisiocampa* spp.)

From year to year these worms become more and more numerous upon fruit-trees. Mr. Stretch in his paper on the genus† cites six species as occurring on this coast,—*C. californica* Packard, as feeding upon *Quercus agrifolia; C. fragilis*, Stretch, from Nevada; *C. constricta*, Stretch, on *Quercus conomensis; C. strigosa*, Stretch, from Yosemite Valley; *C. erosa*, Stretch, from Oregon; and *C. thoracica*, Stretch, as feeding upon Willow. The genus, however, seems to be far more numerously represented. In addition to this I have bred one species from the Sierra Nevada Mountains upon *Ceanothus* and wild cherry (*Prunus demissa*); a second species was found to be very abundant in Los An-

* Insect Life, Vol. II, No. 3, p. 74.

† Papilio, Vol. I, No. 5, pp. 63-69.

geles County upon a species of Oak; a third species was bred in the Santa Cruz Mountains feeding originally upon *Ceanothus thyrsiflorus*, but it was extremely abundant also upon fruit-trees, especially prunes and plums. I also found eggs of one of these moths in Shasta Valley upon a species of wild Currant. Of all the species the most abundant upon fruit-trees was *C. thoracica*, originally feeding upon Willow. This species defoliated most of the trees in Napa and Sonoma Counties last year. On my visit to Sonoma County this month (October), I found numerous old skins still present everywhere upon apple trees. They were either *C. thoracica* or *C. constricta*,—these two larvæ resembling each other somewhat. Fortunately the eggs as well as the larvæ are preyed upon by numerous parasites. Professor Rivers, of Berkeley, informed me that of one egg-mass of *C. constricta* each egg produced a small hymenopterous parasite. I have myself bred something similar from egg-masses on *Ceanothus cordulatus*. The old remedy* will be found best, viz, cut off and burn the egg-clusters during the winter, and collect and burn the nests in spring.

CUT WORMS.

Various Noctuid larvæ are usually numerous and destructive to orchards, vineyards, grain, and vegetables during spring, attacking the young foliage, twigs, and even fruit of trees, while in vineyards they often defoliate large numbers of the vines. As yet I have never been able to obtain any specimens of these larvæ from the injured field for breeding. Dr. Behr, of San Francisco, has shown me one larva that had been received from Santa Cruz, where they injure the vines; he did not, however, succeed in breeding them and the species is as yet not known. The larvæ bore the closest resemblance to those of *Agrotis messoria* Harris (*cochranii* Riley),† yet many of these Agrotid larvæ resemble each other so closely that their distinction can not be made with any certainty. A similar insect, if not the same, was bred from the eggs. (No. 378k). During September and the first of October, 1887, many of these moths came to sugar at Alameda, and were at the time the most common of all so collected. A number of them were confined in boxes but no eggs could be obtained until the middle of October. The eggs were of a straw-yellow color at first and after ten days changed to a dark grayish color, showing that the embryo had come to maturity. The young larvæ, however, did not come out before the rains set in, December 8, at which date they began to issue and continued to appear into January, 1888. They were kept and fed in a room and attained full growth in about five weeks, pupating at the end of March and issuing as moths one month later. This peculiarity of hibernating either in egg, larva, or pupa state during the dry season has been observed in numerous other insects in California, which are

*Professor Riley's Third Missouri Report, p. 120. † *Ibid*, pp. 74–76.

dependent upon such plants as are dried up from July until the rains set in, generally October or November. I will give here the history of one of these:

Agrotis crenulata, Smith.—On September 29, 1887, one pair of these moths was found about 10 p. m. *in coitu* on the upper side of a leaf of *Quercus agrifolia* at Alameda. The female began to lay her eggs the following day and continued until October 10, after which she died. On counting it was found that the number of eggs was 1,026. The young larvæ began to issue on October 12. They are, when full grown, very similar to those of *A. clandestina*,* for which they were taken before being bred. Naturally all such larvæ grow very slowly during the winter months, and reach their full growth about March, when they may be found most anywhere amongst grass, grain, or vegetables. Their chief food, however, consists of grasses. From larvæ that entered the ground in breeding cages on March 12, the first moth came out on April 16. In a state of nature it would be about the same probably, allowing for a week's variation either way in the appearance of the moths according to the situation of the chrysalids. The moths are found from April to July, being most abundant during May and June, at least in localities where food is sufficient. In the Santa Cruz Mountains they were observed to appear soon after dark upon the flowers of *Æsculus californicus* (Buckeye), and could be seen in numbers every night until the flowers disappeared; in other localities, where flowers and natural food are not so abundant, they may retire sooner into their hibernating quarters. During June, 1886, I found them very abundant in a deep, shady cañon in Los Angeles County, amongst leaves, flying up at my approach and settling down a short distance off. On my visit to the same locality one month later not one moth was seen on the wing. But if at this time one searches closer down amongst the dead and damp leaves they will be found in a semi-dormant state. After being exposed a short time they soon fly off to a dark corner and disappear again. In such condition they were observed all last summer in the Santa Cruz Mountains. In open country, distant from woods, they may occasionally be found hidden under or between boards or in old stumps, rubbish, etc. They prefer, however, to hide in the woods amid the dead leaves found there. As in other parts the warm rays of the sun in the spring awaken many of the hibernating insects, so here the first rains in fall will do the same, especially with the Noctuidæ.

NOTES ON THE HABITS OF THE CODLING MOTH AND ITS ENEMIES AND PARASITES IN CALIFORNIA.

During my repeated visits to the Santa Cruz Mountains the past summer some observations were made upon the Codling Moth and its enemies which may be of interest. The moth as a rule is double-brooded in that locality, and no doubt will not differ in its habits to any extent

* Professor Riley's First Missouri Report, p. 79.

throughout California. They may appear somewhat earlier in the valleys. From dates noted in 1887 some of the moths were out on April 22 at Santa Clara, and one larva found then did not produce the moth until May 10. Two days after this they were also observed flying at Alameda. One larva found under bark of pear tree at Los Angeles on July 19, 1886, and evidently of the first brood, did not produce the moth until the end of April the following year. During August, 1887, the moths were abundant at Alameda; on the 2d of the month a cocoon was found about 8 feet from the trunk of the tree, under a fallen apple, from which the larva had issued. The moth from this appeared on the 13th of the same month. Two days later, on a hot and sunny day, while walking through an old apple orchard at 10 p. m., moths started up either from the trunk or lower leaves of nearly every tree and settled down again, generally higher up and on the upper side of leaves exposed to the sun.

Larvæ and chrysalids were found in abundance the same day, and from one of the latter a parasite issued on August 26. This proved to be *Pimpla annulipes*. Up to September 17 moths issued from the chrysalids; one larva that pupated during this month did not, however, produce the moth until December 10. During 1888 the first moth was observed at Alameda as early as March 17, sitting on the upper side of an orange leaf exposed to the sun. But very few of the apple trees were in bloom at this time. Two days later moths began to issue in the house from larvæ collected the previous December. Several issued up to March 28. The present season the moths were not observed in any numbers before May 25 in the Santa Cruz Mountains. The fruit at this time was about 1 inch in diameter. From this date on until the end of June there could be seen at dusk from 25 to 50 on each tree. The place is situated on the east side of the hills. About a half hour after the sun disappeared behind the mountains, and while it was yet visible for nearly that length of time on the opposite hills, the moths began to appear, flying with quick movements around the trees, chiefly near the top, and settling down again upon the leaves or fruit from time to time. This was kept up until towards dark when they became less numerous. During this time both sexes may be readily collected with a long butterfly-net. I have taken many near the ground on the lower leaves and often distant from fruit trees. By their peculiar flight they are easily distinguished from any other species of moths.

About the middle of August, at which time some of the fruit had already been taken off, the second brood made its appearance, yet at this time many larvæ could still be found within the infested fruit, and from material collected then and taken to Alameda, moths came out in numbers until September 12. I was informed that Bartlett pears taken from the trees when the second brood had made its appearance were all sound, not one in twenty being wormy. On examination, however, I found the opposite to be the case. About one pear in twenty only was

found without any eggs or traces of young larvæ of Carpocapsa, the second brood having already begun its destructive work. From these few notes it is evident that with a little care early fruit can be kept almost free from the attacks of the worms, while with later sorts this becomes more difficult, and such fruit generally is rendered useless by the attacks of the second brood, and is fed to pigs.

Enemies.—Enemies of the Codling Moth appear to be quite abundant in California already. I have indeed been surprised in finding minute Chalcids infesting the eggs.* These are not numerous, and had not been observed on eggs of the first brood, yet they may have been present. In fourteen boxes of Bartlett pears examined on August 20 and 21, about seventy parasitized eggs were found, and about an equal number from which the parasites had issued; no doubt some were overlooked. But few of the pears showed traces of worms of the first brood, yet nearly all contained eggs of the second brood and very often more than one. As many as eleven eggs were found upon a single pear. One was found on the stem, six on the pear surrounding the stem, two on the upper half and the other two near the calyx. Of these, two contained parasites, one of which had issued, two were still fresh, and the rest had hatched. I should note here that the pears had been taken off three days previously. In other pears with less eggs, as many as three and even four young larvæ were found. The eggs found upon pears were most numerous near the stem, the others almost invariably on the upper surface of fruit, and but very few on the lower part or calyx. It was also observed that the young larvæ very rarely enter the fruit where an egg is deposited, but generally somewhat lower down, and in many instances instead of going to the center they leave their first mine after a few days and enter at the open calyx. On apples it appears they will oftener enter the fruit from the sides.

Many of the eggs of the first brood were destroyed by some enemy, what I could not learn. They had a brownish and shrunken appearance, and it is probable that they were destroyed by the Chrysopa larvæ, which were present in numbers upon the trees at the time. With the exception of these and the Coccinellid larvæ no other insects were observed in numbers likely to destroy the eggs. This was not observed to be the case with eggs of the second brood, at which time the predaceous larvæ mentioned had disappeared. The other three parasites bred during the summer are all from the chrysalids. The most efficient destroyer of Carpocapsa, however, is a small bat which is always in search of the moths, appearing somewhat later than the latter, but keeping up its chase until dark, when apparently the moths cease their flight and the bats go off in search of other food. Every night during June as many as six of these bats were to be seen flying around an isolated apple tree upon which there were a large number of the moths, not only taking the Carpocapsa on the wing, but very often darting at a

*This parasite is a species of the genus *Trichogramma*.—C. V. R.

leaf to get the resting moth. Of not less value is the larva of a Neuropterous insect, a Raphidia, which is present in numbers. Its long and flat structure together with its activeness enables it to hunt up any larva that may be present under bark or in crevices of the tree.

Not only is the larva devoured but the chrysalis likewise, and without doubt often the mature moth. It was indeed very hard work to find any larvæ or pupæ of Carpocapsa upon trees where the larvæ of Raphidia were present, and the latter occurred upon nearly every tree. As a rule, not more two or three could be found upon one tree by breaking off all the loose bark and examining the crevices, and often none at all. These larvæ are always on the lookout for food, crawling up and down the trees, but being chiefly concealed by the bark. Away from the trunk of the tree, however, more larvæ are found. An old and partly decayed stump or piece of wood lying anywhere near an infested tree will always be full of them; and, as has before been pointed out, many of the larvæ of the first brood, at least, spin up in the dry ground. I will again refer to the Dermestid larvæ mentioned before, not only as destroying the pupa of Carpocapsa but likewise the larva, during the summer season at least. Many apparently sound cocoons when cut open will be shown to contain larvæ and skins of some of these beetles. The contents have been devoured while there is no visible hole in the cocoon, showing that the larva had entered while young. This alone would not be sufficient evidence, but I have also found small larvæ of *Trogoderma tarsale* within the cocoons, and with the larvæ, dead and living, of Carpocapsa.

In two instances the half dead Carpocapsa larvæ showed small holes in their sides which had partly healed up. These no doubt were made by the Dermestid larvæ, which as a rule feed upon dry insect remains, and only kill living larvæ gradually by feeding upon the skin only at first. In many cases they were found with larvæ that had recently died, having already undergone several molts within the cocoons of the last larvæ. They are very abundant, especially around Alameda, as many as four or five large larvæ being often found within the cocoon and feeding upon the dead pupa of *Leucarctia acræa*. In almost any old egg-mass of Orgyia they are found. Whether they will feed upon the eggs or not I have as yet no evidence. Insect collections are not as much troubled by these beetles in California, especially in the valleys, as in the Eastern States. I have often observed them, however, to infest collections in the mountainous districts. A coleopterous (Clerid?) larva was recently found in the Sonoma Valley feeding upon Carpocapsa, but has not yet been bred. Numerous Carabid beetles were always found at the base of trees awaiting their chance to get a bite at the Carpocapsa larvæ. The most numerous of these were *Pterostichus californicus* Dej. and *Calathus ruficollis* Dej. A bright light with a white sheet below and behind was kept burning near the orchard in the Santa Cruz Mountains while the moths were abundant. One female

only was caught in this about one hour after dusk. Never before during my fourteen years of collecting moths with lights, sweeps, etc., have I, within my memory, collected a single Carpocapsa.

THE HESSIAN FLY.

(*Cecidomyia destructor.*)

This insect has been quite abundant and destructive to grain in the central part of the State during the season. A Mt. Eden correspondent wrote to the *Oakland Engineer*, May 2, as follows:

> The Hessian fly has done irreparable damage to the grain in this vicinity. There has been hardly a field that has not been attacked. The prospect for a large barley crop is very good. The wheat crop will be a comparative failure. What is left from the Hessian fly is being destroyed by the rust.

Personally, until this spring, I have had no opportunity of making any observations upon this insect. On May 26, while in the Santa Cruz Mountains, it was noticed that some of the barley had fallen to the ground. On examination, puparia of the Hessian fly were found in places where the straw was fallen. The insect was found at the time in all stages from young larvæ to puparia, and some of the latter had recently hatched. From puparia collected at the time, flies made their appearance until the beginning of July. Other puparia collected about July 1 have not hatched up to date, and the insects are still in the larval state within the puparia. A few specimens of parasites (*Merisus destructor*) were bred from these, and from the same straws several specimens of an *Isosoma*.

During September, 1887, I found puparia, which I took to be those of the Hessian fly, on two species of grasses near here. These were forwarded to Washington, where they arrived in good condition, as stated in letter of October 3d, and the grasses were determined as *Elymus americanus* and *Agrostis* sp. Again during the summer I found the puparia upon several species of grasses in the Santa Cruz Mountains. I shall be prepared next season to give a list of grasses upon which the Hessian fly is found, and also more accurate notes as to the habits of this insect, which, as it would appear, is a very old resident of this coast.

JOINT-WORMS.

(*Isosoma* sp.)

These insects have been abundant and destructive in most wheat-growing sections, and they will continue to be numerous until stricter measures are employed for burning the straw and stubble.

LOCUSTS.

These did not appear in any large numbers except in the northern part of the State and, from some accounts, in Oregon. On my visit to Shasta Valley, Siskiyou County, at the end of July, locusts were no-

ticed in large numbers north of Edgewood and throughout that valley. At Montague I was informed that, on account of the unusually dry season and the crickets and grasshoppers, the crop had been an entire failure in that district. Around this latter place no vegetation except a few sage-bushes were visible. Along the creeks, where a little grass and vegetation was still growing, the locusts were swarming. *Dissosteira obliterata* Thos. was abundant throughout the valley. Even in places where for a half a mile not a shrub or any dry plant was visible they appeared to be happy, but were seen abundantly along watercourses and places still affording some food. *Melanoplus cinereus* Scudd. was more numerously represented in places where food was still to be had, even if dry. But few specimems of *M. femur-rubrum* DeGeer were seen, while *M. packardii* Scudd. was the most abundant of all, feeding upon grasses along streams, and in all the meadows, where it outnumbers all the other species put together. Here they were often observed, always the female, caught in the web of a large spider, which feeds upon them.

M. devastator Scudd. was not met with throughout the summer, while *Camnula pellucida* Scudd. was only seen occasionally in the places visited. Another numerous species in the Shasta Valley was *Hesperotettix pacificus* Bruner, but this was found feeding upon sage-bushes only. About eight other species of locusts were found at Montague, of which *Dissosteira carolina* Linn., *Trimerotropis fallax* Sauss., *Conozora wallula* Scudd., and *Stenobothrus coloradus* Thos., were the most abundant. Two species of large crickets have been very numerous at Montague also joining in the destructive work—*Anabrus simplex* (?) Hald., and the other a species of *Steiroxis*. The common cricket, *Gryllus luctuosus* Serv., was abundant in the central part of the State, often coming in large numbers into cities and into houses.

REPORT ON NEBRASKA INSECTS.

By Lawrence Bruner, *Special Agent.*

LETTER OF TRANSMITTAL.

Lincoln, Nebr., *Nov.* 20, 1889.

Sir: In presenting a report on the insect injuries in Nebraska for the past spring and summer, it is not my intention to mention all the species that have been observed in the act of depredating. Neither do I expect to enter upon a discussion of their life histories. To do this would require altogether too much time and occupy considerable more space than could be allotted to such insects as have been repeatedly described in your various reports upon injurious insects. Suffice it, then, for me to mention briefly a few of the species that most attracted my attention, either by their appearance in unusual numbers, their more than ordinary injuries, or by their peculiar mode of attack.

During the year most of the well-known species that are always present in more or less injurious numbers, were noticed at their regular seasons of appearance. These were, of course, expected; and, unless either very numerous or scarce, were but little noticed. Aside from these, few new or original observations were made during the active season; but several new enemies were observed to act in connection with old and well-known forms.

Since my last report, some time has been devoted to the *Acrididæ* of North America, in the continuance of our work upon that family of the order Orthoptera. The latter work was chiefly in the line of looking up the matter of distribution, the characterizing of new material, and the massing of such additional species as could conveniently be obtained without expense to the Department. Some little was also done in this connection in the study of several minor locust outbreaks in different parts of the country, as, for example, in Utah, Minnesota, and the White Mountain district of the New England States. Of these different outbreaks you already have been advised; Mr. Otto Lugger, of the Minnesota Experiment Station, reporting on that of his State; Mr. C. L. Marlatt, that of New Hampshire, and myself upon that of Utah.

Lawrence Bruner.

Prof. C. V. Riley,
U. S. Entomologist.

FALSE CHINCH BUGS.

Early in the year, during the month of May, two or three species of small hemipterous insects began to gather upon several farms just outside the city limits of Lincoln. These appeared in much larger numbers than is usual for the insects under consideration; and from their size,

order, and general appearance were mistaken for the chinch-bug (*Micropus leucopterus*) by many of the residents. This mistaken identity in the case of these insects was the occasion for much apprehension, as it well might have been had that insect put in its appearance in such great numbers so early in the year. These "false chinch-bugs," for such they were, began work by attacking the weeds and everything else that was green growing in the fields which were infested. The weeds soon disappeared and the insects transferred their attention to apple, catalpa, mulberry, and other small trees. But by far the greatest injury was done to grape-vines. They were all small, and were kept divested of every vestige of new growth for a time, and looked as if the vines never would be green.

The three insects which united in these demonstrations were the following: the False Chinch-bug (*Nysius angustatus*), the Purslane bug (*Geocoris bullata*), and a species that is quite common here in the West among various rank-growing herbs and weed-like plants, and is known to the entomologist as *Trapezonotus nebulosus*.

The first named of these was by far the most numerous, and if working singly would have occasioned nearly the same amount of damage as did the three. The second and the last named were present in nearly equal numbers, perhaps the last being the commoner of the two. All three species gathered upon the main stems and larger branches of the trees and even in clusters upon the scattered remnants of the last year's vegetation. They were pretty well scattered over the fields, but appeared to be most numerous upon some hill-slopes where they had been attracted during early spring and late fall by the warm sunshine. These clusters of bugs were composed of individuals of all ages and sizes, ranging from those apparently but a few days old to those fully matured and winged. An investigation soon disclosed the reason for their abundance in this particular locality. Last year these fields had been permitted to grow up in weeds after the spring cultivation. These weeds, purslane, tickle-grass, stink-grass, and tumble-weeds, made a splendid retreat for the bugs to gather, feed, and breed in, and afterwards to winter in. The present spring being dry weeds and grasses were slow in starting. Not so with the bugs. Eggs were laid at the usual time, these hatched and the little bugs soon exhausted what green vegetation there was for them to feed upon, and which was very slow in appearing on account of lack of the necessary amount of moisture. The trees and vines being deeper rooted sent out their buds and green leaves. These attracted the hungry hordes of bugs, and were at once attacked in bud, leaf, and stem, the bugs inserting their beaks and extracting the sap. The consequence was the injury spoken of above.

As a remedy against the destruction of the grape-vines I suggested covering the vines, which were small ones, with dirt for a week or ten days until weeds had an opportunity to grow, after which time there would no longer be danger, and as a preventive for the future to keep down the weeds in late summer, especially when the season is a dry one.

In habit these three bugs resemble the Chinch Bug to a considerable degree, only that they are earlier in their egg-laying, and that their food-plants are weeds and other herbaceous plants, rather than grasses. They also move about on the wing in a similar manner to that of the *Micropus leucopterus*. Last spring, on one day in particular, the air was full of these and other small hemipterous insects. At just what date this flight occurred I do not remember now, but know it was during the month of May.

The three species referred to above in connection with the injuries recorded, all occur upon ground that has been neglected and allowed to grow up to purslane and Amaranthus. The two latter named are also occasionally found about smart-weed (*Polygonum*) during late summer and fall, while the first mentioned is also inclined to be partial to "stink" grass at times.

CUT-WORMS.

Scarcely a year passes without a report of damages from cut-worms in various parts of the country. Here in Nebraska quite a large number of the night-flying moths belonging to the genera *Agrotis*, *Hadena*, *Mamestra*, etc., are often the cause of much worry and not infrequently the loss of much time and money to the farmer and gardener.

At about the same time that the bugs mentioned above were the most plentiful and doing their injury to trees, vines, etc., the reports of cut-worm depredations began coming in to the station from various districts within and without the city limits. These reports included injuries to both garden and field crops, and from the fact that they were received from widely separated localities, the pest was quite general over the eastern part of the State. Specimens of at least a half dozen distinct species of the worms were received by me, along with the statement that they were the authors of the injury. Among these I recognized *Agrotis annexa*, *A. suffusa*, *A. messoria*, *A. saucia*, and *A. clandestina*.

So abundant were several species of these worms that they literally cultivated the ground at places where they burrowed during day-time. Nor did the worms content themselves with feeding upon cultivated plants alone, but also, in many instances, kept down the weeds. Here in the city of Lincoln, upon a vacant square that had been used by the boys as a base-ball ground, and where the ordinary "pepper-grass" was growing in profusion, the *Agrotis annexa* finally succeeded in clearing the ground of this weed. So voracious did the worms become before maturity that the pepper-grass was even cut off and the stems drawn into their retreats in the ground, where they might be devoured during day-time. On cloudy days the worms even ventured forth to feed openly by daylight, scurrying back into their holes when the sun came out for a moment. In the hard trampled ground their holes were smooth-cut and presented a very interesting sight indeed when the occupants issued forth and quickly returned upon the least disturbance, like

some animal of greater intelligence. The larva of this particular species of *Agrotis* is exceedingly active, reminding one not a little of some of the chipmunks among the rodents.

A second species that much interested me is the larva of an *Agrotis* sp. that was exceedingly numerous upon the college farm and adjoining tracts to the eastward of the city. This latter worm worked on various plants in the garden, but on the farm showed decided taste for clover. Here it literally "lived in clover" in large numbers. The different kinds of clover growing in the experimental plats suffered much. It was here that one of the instances above cited of cut-worms cultivating the soil occurred.

The remedies used against these different cut-worms varied somewhat in their character; but they were chiefly hand picked or crushed. Many of the worms also perished from the attacks of predaceous beetles either in the larval or imago stages, and of parasites of one or another sort. A few of them also from diseases that resulted from the presence of fungi or bacteria. The parasitized worms were the result of the eggs laid by Tachina flies in most cases. The *A. annexa* larvæ suffered most in this respect, on account of their habit of coming out to feed during the day-time.

ARMY-WORM.

As the State grows older in its settlement the reports of Army-worm depredations become more frequent year by year. Last year I reported the appearance and damage by this insect in the extreme northwestern part of Nebraska, as well as in portions of southwestern Dakota. During the present year several localities in northeastern Nebraska were overrun to a limited extent by the larvæ of *Leucania unipuncta*. None of these areas infested were of very great extent, nor was the injury committed complete in any of the cases coming to my notice. Millet and oat fields were the chief sufferers.

A small black fly was bred from larvæ received from Mr. J. M. Seymore, of Pender, Thurston County. This fly has frequently been observed by me at various points in northern Nebraska, where I have taken it in my net when sweeping for other insects on the prairie. It must be a regular enemy of *Leucania unipuncta*, and perhaps also of other allied species, since it is by no means an uncommon insect every year. Others of the flesh-flies (Tachinidæ) also act as guards against this insect's rapid increase, as can readily be seen from the fact that many of the larvæ taken have the eggs of these flies attached to their bodies.

Visiting again this year the region last year reported to you as having the insect present in injurious numbers I was pleased to find that the Leucania had not appeared in numbers sufficiently great to attract the attention of those persons who lost crops by their depredations last year. In fact I am pretty confident in asserting that there are no grounds for fearing this insect next year, in the State of Nebraska at least.

THE GREEN-LINED MAPLE-WORM.

For the third time, now, many of our soft maple trees in the city of Lincoln have been entirely defoliated by the larvæ of *Anisota rubicunda*. This insect has been steadily increasing for the past three years, and if it does not soon die off by some epidemic disease or is killed by parasites the growing of this tree will be very difficult. This state of affairs is due entirely to the negligence of our citizens in general, who, it appears, can not be induced to spend the little time necessary for the destruction of insect pests that attack their shade trees, garden and farm produce, and flowering plants. The entomologist can not kill all the insects, good and bad, in the country; neither are his words of advice heeded in the least when he tells how each insect enemy is to be gotten rid of by means of the least labor and expense to those who should be most interested.

THE BLUE-GRASS WEEVIL.

For the past two years *Sphenophorus parvulus* Gyll. has been increasing quite rapidly in numbers, so that now it has come to be one of our commonest beetles in the city of Lincoln, at least, if not elsewhere. From the fact of its frequenting sidewalks, or being concealed under boards, sticks, and stones that were left lying about on the University campus, and on lawns elsewhere in the city, I began an investigation as to its probable breeding place. This study has led to the discovery of its feeding upon the roots of the common blue-grass (*Poa pratensis*). So plentiful has the insect become in some lawns that the sod has been entirely killed over large patches.

The larva is a short, thick, whitish grub, like those of other species of the genus, and measures from 4 to 5 millimeters in length when fully matured. The beetles appear twice a year, *i. e.*, in the spring and early fall, the insect probably being double-brooded. Some of the beetles may come out in fall, while the remainder may lie over winter as pupæ. The fully matured larvæ were found early in June, while others were observed last October. Damp and well-watered lawns appear to be infested fully as badly, if not worse, that those that are dryer, although they do not show the injury nearly so quickly in the former as in the latter case.

While looking for larvæ during the latter part of last May, numerous specimens of a small white "hair-worm" *Mermis* or *Gordius*, or some allied genus, were found scattered through the soil. These were only obtained at very damp places under trees on the University campus, and as a rule were tightly coiled. Whether these would have or had been in any way connected with the Sphenophorus larvæ, I do not know, as I am not sufficiently well acquainted with these forms nor with their life-histories. Various ground-beetles (*Carabidæ*) and their larvæ certainly do devour the larvæ of Sphenophorus, since the former were also quite common in the localities where the latter abounded. No experi-

ments were carried on with a view to finding a remedy against the injuries of this weevil.

THE CORN ROOT-WORM.

(*Diabrotica longicornis.*)

This insect is becoming alarmingly common in the counties of eastern Nebraska and those of western Iowa; and, judging from the general food habits which the imago appears to be developing, it may soon become a much more dangerous pest than we at present imagine. During the past summer and fall the beetle has been almost omnipresent, so common was it in the vicinity of Lincoln. It was found upon a large variety of plants belonging to different orders. It was beaten from trees such as maple, box-elder, elm, ash, willow, cotton-wood, and oak. I found it rather common among the grasses and obtained it in plenty in gardens where it was feeding upon the leaves of radishes and turnips, in several instances completely riddling these latter with holes. As late as September 28, the beetle was still quite active during daytime, and quickly took to flight upon being disturbed. In August it was observed to be nocturnal in its movements, as was to be seen by the large numbers of the beetles that were attracted to and gathered about the electric lights. On the morning of the 15th, 260 specimens of the beetle were taken from the globe of a single arc light that hangs in front of University Hall upon the campus of the State University. These had all been attracted to and caught in the globe in a single night. Whether or not these came from the farms in the surrounding country I can not say. Might not the species work in the roots (for the larva is a root-borer) of some other plant or plants beside corn? At any rate it is my present intention to look into the life-history of the Corn Root-worm a little more closely during next season. It is getting to be by far too common an insect in these parts for us to be running chances in dealing with it. Rotation of crops may or may not always prove to be a remedy against its depredations.

INSECTS DETRIMENTAL TO THE GROWTH OF YOUNG TREES ON "TREE CLAIMS" IN NEBRASKA AND OTHER PORTIONS OF THE WEST.

For several years now I have been interested in the study of the insect pests that render the growing of young trees upon claims entered under the "timber-culture act" quite a difficult and tedious matter. This interest in the subject had its origin partly in personal experience and partly from the numerous complaints of others who have experienced great difficulty in securing a sufficient growth in their young timber within the limitations for making final proof. Not infrequently has it been the misfortune for those striving to gain titles to Government lands under this act to have their trees completely defoliated for several years in succession. Nor have these injuries been confined to any single kind of tree. Since commencing the study of the subject I have either

seen or heard of all of the following species suffering alike from this cause: Ash, Box Elder, Soft Maple, Cottonwood, and Willow. The honey locust, too, has been subject to defoliation by insect enemies when growing as hedges upon the uplands of the semi-arid regions west of the 97th meridian. Some of these trees thus attacked were killed outright, while others were set back a year or more by each defoliation.

Several different lines of investigation have been followed in the study of this subject, viz, the comparative freedom from insect attack of the various kinds of trees; the influence of topography upon the growth of each kind of tree, as well as upon the increase and development of the insect life thriving upon the tree; also the comparative abundance or absence of birds and parasitic insects in the different regions, and what relation these bear to insect depredations. Of course, when fully carried out in the several lines indicated above, the investigation of such a subject can not fail to be quite extensive and result in some good to the parties most concerned. For the present paper, however, only a few of the most important of these insect enemies will be mentioned, and then only cursorily. Of these there are about thirty species belonging to the orders Coleoptera, Hymenoptera, Lepidoptera, Orthoptera, and Hemiptera. Most of these insects that I wish to call attention to are quite general in their distribution, and therefore as well known to you as they are to those living in the "tree-claim" region. My report will then simply consist of a statement as to their abundance, distribution, and the amount of injury done by each species. To do this the following table will best express my wishes and at the same time be least cumbersome. All of the species therein mentioned have been either observed by myself or were reported by others as occurring in injurious numbers during different seasons upon tree-claims located in Nebraska, Kansas, and Dakota.

Insect.	Tree.	Insect.	Tree.
HYMENOPTERA.		*Cressonia juglandis* A. & S.	Walnut.
Cimbex americana Leach	Willows.	*Clisiocampa americana* Harr.	Most kinds.
Monophadnus barda Say	Ash.	*Clisiocampa sylvatica* Harr.	Do.
COLEOPTERA.		*Datana angusii* G. & R.	Black Walnut.
Lina scripta Fab	Willow and Cottonwood.	*Anisota rubicunda* Fab	Soft Maple.
Chrysomela sp	Do.	*Hyphantria cunea* Drury	All kinds.
Disonycha pennsylvanica Ill.	Willow.	*Apatela populi* Riley	On Cottonwood.
Chrysobothris femorata Fab.	Box Elder and Maple.	Do	Willow.
Lachnosterna (several species).	All kinds.	Do	Maple, Box Elder.
Epicauta cinerea Forst	Honey Locust, Coffee Bean.	*Tortricid* (——)	Honey Locust.
LEPIDOPTERA.		*Sphinx*	Ash.
Papilio turnus Linn	Ash.	Do	Elm.
Vanessa antiopa Linn	Willow, Elm.	*Tortricid* (——)	Boring twigs of Hackberry, Box Elder.
Platysamia cecropia Linn	Maple, Willow, Box Elder, etc.	ORTHOPTERA.	
Telea polyphemus Cramer	Maple, Elm, Box Elder, etc.	*Œcanthus niveus* Serv	Stems of various trees.
Triptogon modesta A. & S.	Willow, Cottonwood.	*Œcanthus latipennis* Riley.	Stems not so common.
		Melanoplus spretus Thos	Foliage of all when numerous.
		Melanoplus femur-rubrum DeGeer.	
		Melanoplus differentialis Thos.	

Almost all of the above named insects are sufficiently numerous at times, when working alone, to kill or at least to greatly retard the growth of the tree or trees upon which they feed. Of course, they do not all occur at once in any given locality in such overwhelming numbers, nor are the injuries the same every year; but quite frequently two or more of the species are found feeding in company upon the same tree in numbers sufficiently great to do harm. In addition to the species named above there are a great many others that are also known to attack and injure the trees growing upon tree-claims; but these latter have not yet made their presence so strongly felt as to force us to place them on the list of insect pests in connection with tree-claim culture. For a description and life history of many of these the reader is referred to Bulletin No. 7 of the United States Entomological Commission, entitled "Insects Injurious to Forest and Shade Trees."

Causes for these Insect Injuries.—There is a cause for everything, so in the present instance we must look for one or a combination of causes that work together in producing the undue increase of insect life upon the prairies when new varieties of plants are introduced. A very superficial survey of the ground will quickly reveal to us some of these causes.

In the first place, there are always a few dwarfed trees of most of the kinds that are usually planted upon claims. These trees are scattered along the water courses, in ravines and gulches, and a few other localities that are protected from the fires which have annually swept over the broad prairies for generations. These few trees furnish food for small colonies of the various species of insects that we have named. There are always enough of them to very quickly stock a claim close by upon which small trees are planted that are to their taste. Then, too, all of these injurious insects are of a hardy nature, used to a precarious life, and are strong fliers capable of making comparatively long journeys in search of food for themselves and their progeny. They are, in fact, the nomads of the insect world, capable of withstanding the vicissitudes belonging to a life upon the vast prairies where the more delicate parasitic forms could not live or even find shelter. Then, too, their requirements for quarters in which to pass the long, cold winter months are less complex than are those of the species that come later on.

In the second place, the country being destitute of groves of timber among the branches of which insectivorous birds can find shelter and build their nests most of these insect destroyers are absent. Of course, the absence of so great a factor as are these birds in the ridding a country of its insect pests soon becomes apparent in the increase of the latter and of the accompanying injury done by them. The absence of groves, too, not only keeps away the feathered tribe, but also prevents many of the more delicate parasitic and a large number of the predaceous insects from becoming established in the region. The majority of these latter forms of insects, as before stated, are such as require

sheltered retreats in which to lurk or to get away from the hot dry summers and the long cold winters.

In the third place, the comparative aridity of the region where these claims are located renders the growth of them somewhat slower than where the precipitation is more bountiful. This slowness of growth, while it is an advantage in one respect, aids the insect foes to a conderable extent in their work of destruction. A rank and rapid growth places a tree out of danger from external enemies much more quickly than will a slow growth. At the same time in rank growth a much greater amount of food is furnished for the same number of insects, and as a consequence less injury to the tree results than would were the growth slower.

A fourth cause for the rapid increase among these different insects in new regions is the absence of such fungoid diseases as are known to attack and kill various of these pests. After awhile, however, the germs of these diseases become diffused through the soil, vegetable débris, and about the encumbering growths, buildings, etc. These germs are carried around by the elements and other agencies, and in time some of them find lodgment within the bodies of such insects as are susceptible to their growth. The result is disease and death.

Comparative Freedom of different Trees from the Attacks of Insect Pests.— Up to the present writing I have not sufficiently investigated this portion of the subject to be entirely positive in my assertions as to the kind or kinds of trees most nearly exempt from the attacks of insect foes in different regions. None of them are entirely free; but that there are trees which suffer less than others in this respect is a well-known fact, and can be seen at any time where several kinds are growing side by side or in the same grove. Again, a particular kind of tree might be troubled in a given locality, while in another it would be comparatively free. Some trees also suffer while small, and others are usually injured after they have gained considerable growth and age. These variations with regard to insect attacks among different trees, and of the same kind at different ages, are governed by laws the explanation of which would require much more time and space than I have at my command. By looking over the list of insects mentioned above it will be seen that no reference is made of any species injuring either the Catalpa or Russian Mulberry. The Ash is affected by three, each of which at times strips it of foliage while young; the Box Elder by two or three; the Willow by a dozen or more; the Cottonwood by four or five; the Soft-Maple by several; the Elm a couple; the Honey Locust two, etc.

In treating this subject only such insects have been mentioned as have been ascertained to attack the various trees during their first few years of growth, and before they have attained any great size. Other species of insects injure these trees later on; but, as a rule, these latter

are less destructive to them save in a few instances. Only a very few borers work in healthy young trees in this region.

Remedies tried and suggested.—Only a few remedies have been generally tried against these pests in the region of tree claims, and most of these were confined to the various methods of "hand-picking" and crushing. Spraying and dusting with poisons and kerosene emulsions, or the use of road dust, ashes, air-slaked lime, etc., have been reported only in a very few instances. Any or all of these methods of warfare when properly carried on and used intelligently, in accordance with the habits of the insect that is being fought, will repay one for the time thus spent.

LOCUSTS OR GRASSHOPPERS.

Aside from several local outbreaks there has been no special damage done during the year by locusts within the United States. Of course, you are already acquainted with the particulars in connection with the local injuries, of which the chief are the following: The Rocky Mountain or migratory species at Nephi City, Utah; the same in Otter Tail County, Minnesota; and the lesser and red-thighed species in the mountain districts of the New England States. The Utah outbreak was partly investigated by me at the time (May) of its occurrence, through correspondence with the Hon. James B. Darton, of Nephi City. That gentleman supplied me with specimens at different times from which the insects under consideration were determined. The conclusions at which I then arrived were reported to Mr. Howard in your absence. If I remember rightly, both the Rocky Mountain (*Melanoplus spretus*) and the California locust (*Camnula pellucida*) were found among the material received from Mr. Darton. The Otter Tail outbreak has been very carefully written up by Mr. Otto Lugger, of the Minnesota Experiment Station; while Mr. C. L. Marlatt, of the Entomological Division, has reported on the New England outbreak.

While it is not my intention to devote much time to the subject of locust abundance and injuries, I do wish to say a few words concerning the fungoid disease known as *Entomophthora calopteni* of Bessey. During the present summer this disease has been unusually abundant in and around the city of Lincoln, Nebr. Several species of our native locusts were attacked by it; but the large yellow one, known as the *Melanoplus differentialis* Thomas, was destroyed by the thousands. Whether the fungus in question was more plentiful than usual, and did its work of extermination more effectually than during previous summers; or, whether it was on account of my being surrounded by a number of students in botany, and located next door to the botanical laboratory, that attracted my attention to these, I do not know. The impression is, however, that the former is the true explanation. On the University campus alone, where *differentialis* hatched quite plentifully and began doing considerable injury to various small trees and

shrubs, there must have been several thousands of the hoppers destroyed by the disease. Soon after the locusts became fledged some of them were observed to die after first showing signs of disease. After the disease first became apparent among the locusts, it spread, or at least appeared in other portions of the city, the number of dead and dying locusts increasing daily. So fatal did the disease finally become upon the University campus that but few of the *differentialis* escaped to deposit eggs. I know that three or four of the botanical students each collected the dead locusts by the chalk-box full to use as specimens in their line of work, and for exchange, while I gathered many of them myself. During the latter half of August, and early in September, at almost any time one might have secured from fifty to a hundred or more specimens of the dead locusts in a few moments, by simply going outside of the science hall a few yards.

So rapid was the final action of the *Entomophthora* (or *Empusa*, as it has more recently been called) that not infrequently the locusts were found still in copulation, one or the other of the sex being dead. When they were found in this condition, the female, though not always, was the first to succumb. This would not, however, prove anything as to the comparative fatality of the disease as far as the different sexes are concerned. There are other matters to be taken into consideration before we can come to a definite solution of comparative immunity from attacks upon the different sexes of an insect by a disease like the present.

Just how long a time is required for the full development of the fungus after an insect is first attacked I am not prepared to state; neither can I give an account of the various stages through which the fungus passes during this development from the original spore to the stage where such spores are reproduced. Nor am I posted as to all symptoms present during the different stages of the disease occasioned by the fungus within the tissues of a living locust. All that I know is, that shortly before death the stricken hopper climbs up some stick, weed, or blade of grass, to which it clings frantically with its anterior and middle pairs of legs. When found dead these always have their head uppermost.

Whether or not invariably fatal I can not say; and imagine that to ascertain this would be no easy task. I am also quite ignorant in reference to its capability of being artificially spread, since I have had no opportunity to experiment in that direction. Besides, the disease does not appear to be common to all species of locusts alike; or if it is, we do not know it. The subject will bear a much more careful study than has thus far been devoted to it. From an economic standpoint there is still a great deal to be learned concerning insect-attacking fungi, as a few recent experiments in this line clearly demonstrate.

Before leaving the subject of this locust-destroying fungus I wish to add the following notes, prepared for the present paper at my request

by Prof. C. E. Bessey. They will show the most recent views of botanists as to the systematic position of the plant in question:

Entomophthora calopteni Bessey.—The original description of this species appeared in the American Naturalist for December, 1883 (page 1280). It is reproduced here verbatim:

"I. Empusa stage, not seen.

"II. Tarichium stage: Oospores globular, or from pressure somewhat irregular in outline, colorless, 36 to 39μ. in diameter; walls thick (4μ.), colorless, smooth; protoplasm granular, after as if composed of many small cells, often with a large round vacuole. Occurring as a clay-colored mass in the body cavity and femora of *Caloptenus differentialis*.

"Ames, Iowa, August and September, 1883."

Specimens of this fungus collected in Wisconsin by Trelease and Seymour were distributed under the name given above by Ellis and Everhart in North American Fungi, No. 1801. In April, 1888, Mr. Roland Thaxter published, in the Memoirs of the Boston Society of Natural History, an important paper on The Entomophthoræ of the United States, in which he revises the species of the group, and adopts the older generic name *Empusa*, first proposed by Cohn in 1855, in preference to *Entomophthora* proposed by Fresenius in 1856. Moreover, Mr. Thaxter concludes that the fungus described above is identical with one described as *Entomophthora grylli*, by Fresenius, in 1856. Specimens of this species were distributed in 1885 by Dr. Farlow, in Ellis' North American Fungi, No. 1401. Our species thus appeared in Mr. Thaxter's paper under the name of *Empusa grylli* (Fres.) Nowakowski.

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